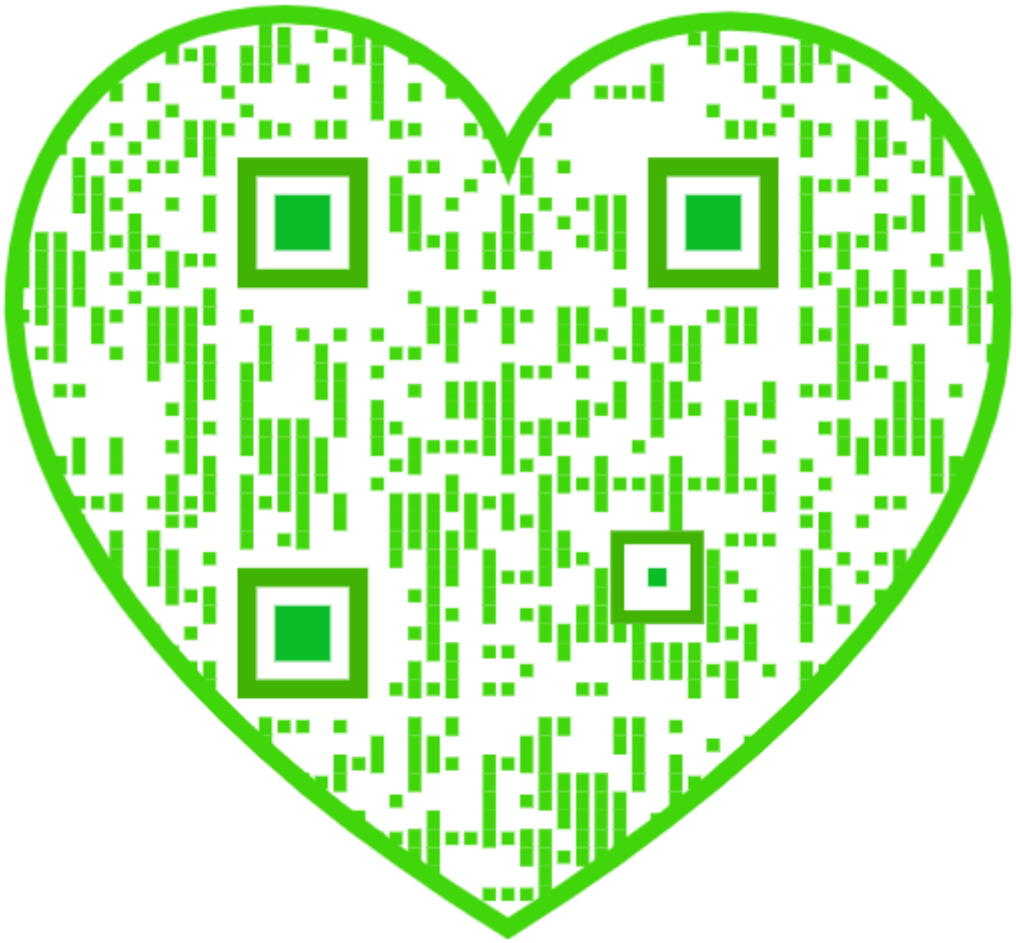
TS
965
.R57

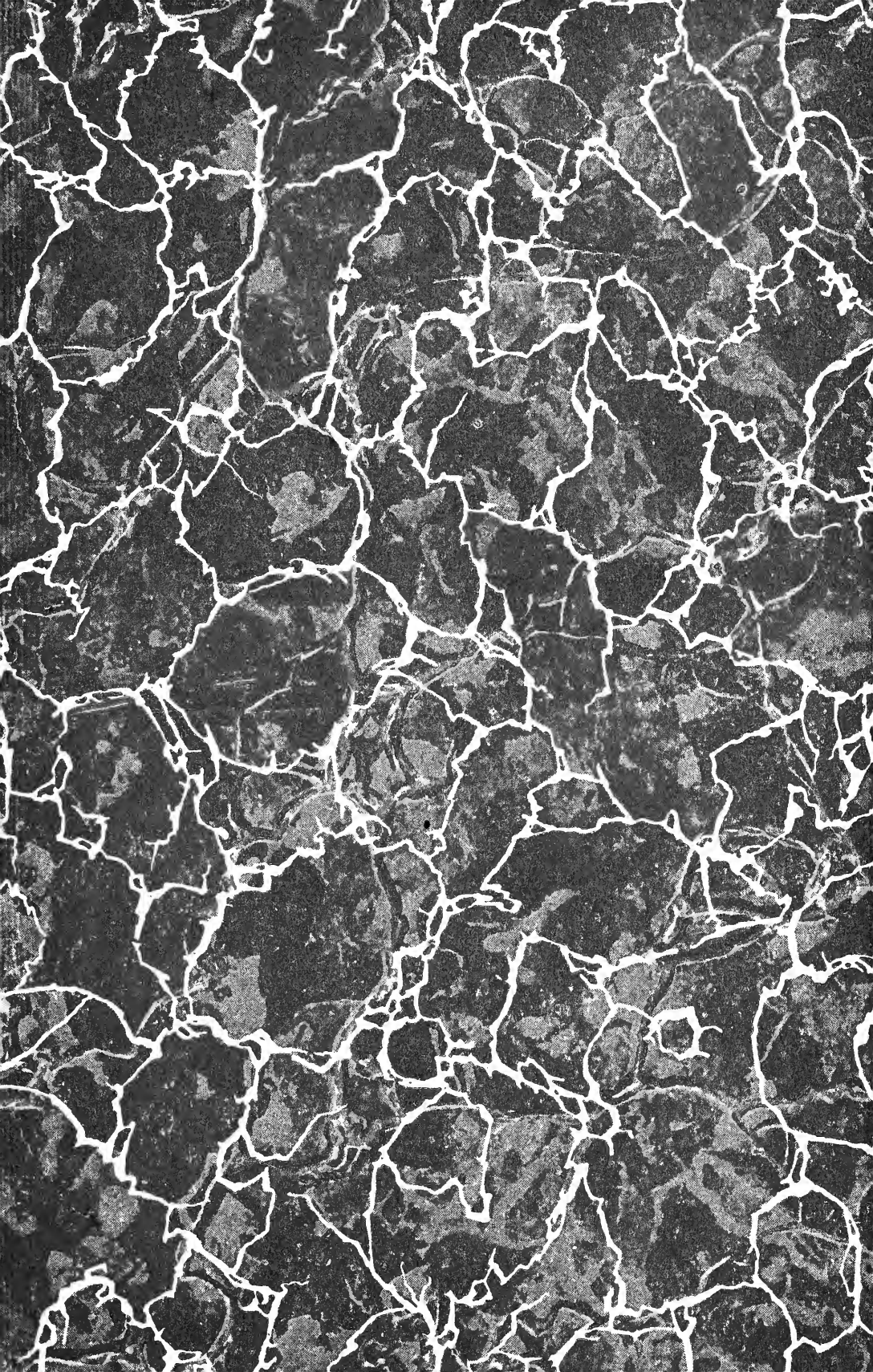
MANUFACTURE OF LEATHER

INTERNATIONAL
TEXTBOOK COMPANY



Class TS 965
Book .R57

PRESENTED BY



Manufacture of Leather

By

ALLEN ROGERS, Ph. D.

PRATT INSTITUTE, BROOKLYN, N. Y.

MANUFACTURE OF LEATHER
Parts 1–3

393

Published by

INTERNATIONAL TEXTBOOK COMPANY

SCRANTON, PA.

40·26073

TS965
.R57

Manufacture of Leather, Parts 1, 2, and 3: Copyright, 1922, 1909, 1902, by International Textbook Company.

Copyright in Great Britain

All rights reserved

Printed in U. S. A.

Gift
Publisher
Dec. 29, 1939

40-26073

International Textbook Press
Scranton, Pa.

80050

CONTENTS

NOTE.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

MANUFACTURE OF LEATHER, PART 1

Pages

Heavy, or Firm, Leathers..... 1–45

Intoduction 1– 3

Definitions and classification; Hide structure.

Treatment of Hides..... 4–18

Soaking; Cold-sweat system; Warm-sweat system; Liming; Unhairing and fleshing; Leidgen unhairing machine; Deliming; Plumping the hides.

Sole-Leather Manufacture 19–45

Methods of tanning; Oak leather; Oiling and drying; Rolling; Treatment of the hides; Bleaching; Union leather; Quick sole-leather tannage.

MANUFACTURE OF LEATHER, PART 2

Heavy, or Firm, Leathers—(Continued)..... 1–42

Sole-Leather Manufacture—(Continued)..... 1– 3

Oak-tanned belting leather; Harness leather.

Vegetable Tanning Materials..... 4–21

Classification of tannins; Wood and bark extracts; Ott bark mill; Williams' patent bark shredder; Vat leaching.

Analysis of Tanning Materials..... 22–35

Analysis of bark, wood, etc.; Teas percolator extractor; Determination of non-tannins; Analysis of tanning extracts; Analysis of tan liquors.

Analysis of Leather..... 36–42

Determiation of moisture; Determination of ash; Determination of oil; Determination of nitrogen; Determination of water-soluble materials; Determination of glucose.

MANUFACTURE OF LEATHER, PART 3

	Pages
Limp, or Light, Leathers	1–54
Process of Manufacture	1
Automobile and Upholstering Leathers Stoning jack; Splitting machines; Daubing; Embossing.	2– 9
Bag, Case, and Strap Leather Stuffing materials; Hand and drum stuffing; Fat-liquoring; Whitening.	10–17
Side Leathers	18–20
Shoe, Glove, and Fancy Leather Working out skins; Shaving; Staking; Seasoning; Surfacing.	21–27
Vegetable-Tanned Calfskins	27–29
Vegetable-Tanned Sheepskins	30–31
Hogskins	32
Tawing	32–34
Oil Tannage	35–37
Chrome Tanning Two-bath chrome-tanning process; One-bath chrome-tanning process; Fat-liquoring; Box calf; Matt calf; Glazed kid; Chrome patent leather.	38–48
Dongola Leather	48–49
Leather Dyeing	50–52
Measurement of Leather	52–54

MANUFACTURE OF LEATHER

Serial 416A (PART 1) Edition 3

HEAVY, OR FIRM, LEATHERS

INTRODUCTION

1. Definition and Classification.—The term **leather** is applied to the product obtained by the treatment of hides or skins of animals with certain reagents that convert the animal tissues into a tough, opaque, pliable, and fibrous substance which is not subject to putrefaction.

2. The pelts of animals come to the tanner in four conditions: *green* or *market* (fresh from the animal); *green salted* (when salt has been rubbed on the flesh and the skins placed in piles to cure); *dry salted* (same as green salted but afterwards allowed to dry); *flint,* or *dry, hides* (usually stretched and allowed to dry in the sun). According to their size, these pelts are divided into three general classes, namely, *hides, kips,* and *skins.* **Hides** comprise the coverings of larger animals such as the cow, horse, camel, and walrus. These are used for heavy leather manufacture such as shoe soles, machinery belting, harness, and other purposes where stiffness and strength are required. They are also often split for the purpose of producing shoe leather, bag, case, strap, automobile, and furniture leather. **Kips** are the undersized animals of the same species. **Skins** are obtained from small animals such as sheep, goats, and calves. Kips and skins are used in the

COPYRIGHTED BY INTERNATIONAL TEXTBOOK COMPANY. ALL RIGHTS RESERVED

manufacture of light leather for shoe uppers, pocketbooks, bookbinding, gloves, and fancy articles. Both hides and skins are graded according to weight and imperfections, the latter being in the nature of cuts, brand marks, hair slips, and grubs. Diseased hides are some times found and are a source of great danger to the tanner.

3. Hides are obtained from the various slaughter houses over the country and are known as *domestic,* or *native.* They are also obtained from other parts of the world and are usually known by the name of the country from which they originate.

HIDE STRUCTURE

4. Analysis of Skins.—At first glance, the pelts of various animals appear to have little in common. On closer examination, however, a very close similarity will be observed. In structure, all animal skin is made up of several readily defined layers. The skin is not merely a covering for the animal, but also serves as a container for nerves and secretive glands, and as a bed, or ground, for the hair, or fur. It is made up of two principal layers: the *epidermis,* or *cuticle,* and the *corium,* or *true skin.* These two layers are totally distinct in structure, origin, and functions.

5. The **epidermis** is a thin covering of the true skin and is entirely removed before the tanning operations begin. In life, the upper, or external, part is being constantly worn away, falling off in the form of dry scales. The interior part of the epidermis is made up of numerous living nucleated cells; as the surface of this layer is reached, these cells become flattened and finally dry up and form the exterior part of the epidermis and ultimately drop off as dead scales. These cells, which renew the horny external tissue of the epidermis, are in turn renewed by vessels situated in the corium, or true skin. The epidermis does not combine with tannin and is therefore removed, laying bare the true skin, which is known to the tanner as the *grain.*

6. The **corium,** or *true skin,* is the skin with which the tanning agents combine to form leather. There is an intermediate albuminous layer between the corium and the epidermis. Both layers are composed of interlaced bundles of fiber running across and above one another and parallel to the surface of the skin. These fibers are surrounded by fluid matter, which serves to keep the skin in a moist and pliable condition. On removal of this fluid the fibers alone remain, and if dried by a gentle heat they assume a horny appearance and become in substance about one-third of the raw hide.

The corium determines the quality of the leather that can be made from a hide. Its thickness, flexibility, and strength are reproduced in the leather. Between the fibers of the corium is an albuminous substance called **coriin:** in a dry state this holds and connects the fibers.

The connective tissue of the corium gives form to the skin, the intercellular substance, coriin, lying between the fibers. When boiled with water, these connective tissue fibers form glue, losing their organized structure, and making a homogeneous jelly.

7. The intercellular substance is probably a decomposition product of the connective tissue. This coriin is soluble in lime water and other alkaline solutions; frequent treatment of the skin with these reagents withdraws fresh quantities of soluble matter with every treatment. This fact should be noted in connection with the liming of skins to remove the hair.

Dilute inorganic acids swell the connective tissue. The swelling of the skin by acids is made use of to facilitate tanning; it not only makes the skin more sensitive for the reception of the tanning material, but also effects the disintegration of the fiber bundles into individual fibers, thereby increasing the surface.

8. The **under skin** is made up of loose connective tissue, embedded in which are the sweat and fat glands, the blood vessels, and muscular fiber. Fig. 1 shows an enlarged microscopic transverse section of the skin in which the Malpighian net, or lower layer of the epidermis, is shown at *d*; the corium,

at *b*; the lobules of adipose tissue, at *m*; the external orifices of the sweat glands, at *a'*; a hair follicle, at *y*; a shaft of hair in the hair follicle, at *z*; a hair papilla, at *i*. At *l* is illustrated the connective tissue of the under skin, showing the sweat glands *a*, with the ducts *c*, through which the sweat passes to the surface of the skin; at *k* is shown a hair bulb, and at *e* are shown openings of the sebaceous glands. The horny outside layer of the epidermis *h* shows hair, as at *f*, or wool at different places. The hair is not embedded immediately in the surface, but in the capsules, or sacs, being continuous with the epidermis and reaching down to the corium.

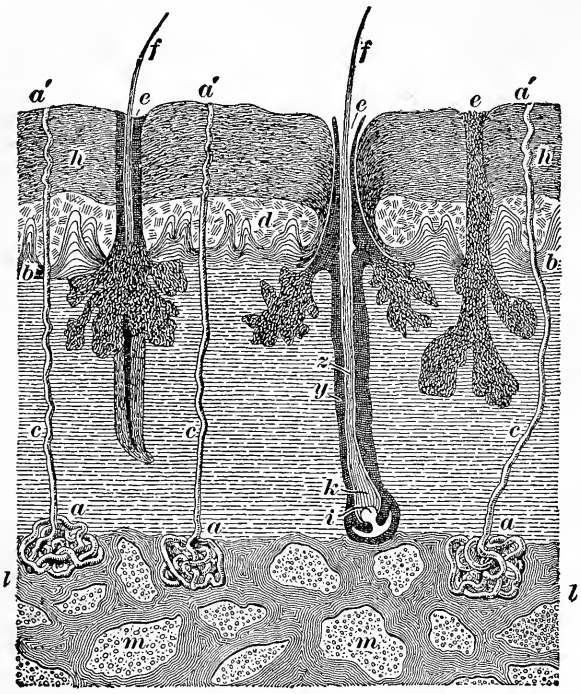


FIG. 1

TREATMENT OF HIDES

9. Some operations in the manufacture of leather are followed, with more or less variation, in all branches of the industry, and, to save repetition, these will be treated generally, variations being noted in descriptions of the tanning processes necessary for the production of specific kinds of leather. These variations are so numerous that it will be impossible to enumerate them all, but enough will be noted to indicate what latitude exists in the application of the general principles involved.

10. Soaking.—Whatever may be the class of hide in use at the tannery, the first operation is that of soaking.

This is always done by means of water, with or without the addition of chemicals. The various kinds of hides require different treatment as to mechanical handling, character of the soak, and the duration of the soaking. Whether the hide is *green* or has been dried with preservatives (in this case these preserving agents must be washed out), the dirt, blood, and dung must be removed, and the hide brought back to a state similar to that in which it was when taken from the carcass. All the foreign matter goes into the soaks, and only a short time elapses before the water becomes filthy.

Where hard water is used, it is customary to add some softening agent, as borax, soda ash, or caustic soda, since soft water is better adapted to soaking purposes. Much valuable hide substance is lost in many tanneries through the use of soaks that have become putrid. An old soak gives better results than a new one, but if the vat is allowed to become putrid, depletion of the hide takes place, and the loss from this cause more than offsets the time gained. Plenty of pure water with a little borax or soda, if needed, is a much more effectual cleanser and softener than a putrid liquor.

11. The general form of receptacle for the soaking is a pit or vat sunk in the ground. Wheels or drums have been used, and in some places are still employed, but the ordinary vat is the most convenient receptacle for the purpose. The hides are either hung in the water on racks or thrown in and spread out. Dried hides are generally placed in piles in the pits and the water then run on them.

While in the soaks the hides must be watched by skilled workmen so that they will not become putrid. Thin hides must be removed as soon as they become soft, without waiting for the thicker ones to soften. The thin parts of all hides must be carefully watched, in order that they will not become damaged while the heavier parts are softening.

12. Hide Mills.—Where heavy hides are being made into sole leather it is customary to use **hide mills,** also known as *kickers,* or *stocks.* A hide mill is merely a heavy iron shoe on the end of a vertical beam keyed at the other end. A

backward-and-forward motion is imparted to the beam by a heavy shaft and the shoe moves in a heavy receptacle containing the hides. The hides are kept constantly in motion in contact with running water, and a couple of hours of this treatment is more beneficial than a day's quiet soaking. The hides are first put in the soaks until they become softened, and the mills are then used to finish the operation. Similar, but lighter, mechanical contrivances are used for the same purpose where lighter pelts are treated.

Many tanners run the partly softened stock in a drum. Here the tumbling action helps materially to hasten the softening. For green-salted hides it has also been found advantageous to do away entirely with pit soaking, simply depending upon milling the stock in the drum in the presence of running water.

13. Depilation.—Having brought the stock to a soft and clean condition, the next step is to remove the hair and epidermis, the operation being known as *depilation*. This may be accomplished in several ways, the oldest of which is known as *sweating*. Sweating may be carried out either in a cold or warm pit or cellar and is termed *cold sweat* or *warm sweat*. In both cases the results secured are due to incipient putrefaction.

14. Cold-Sweat System.—As used in the United States, the cold-sweat system is carried out as follows: The sweat pits are vaults built of stone, with the proper apertures for ventilation, in order to regulate the temperature. Tight doors are provided, and these may also be used for ventilating purposes. After the hides are thoroughly soaked and softened, they are hung over poles or suspended by the edges in the sweat pit. The doors are closed until the putrefaction begins, and when this takes place careful watching is necessary. The hides are carefully scrutinized, and those in which the putrefaction is far advanced must be removed at once. The presence of a hide in the sweat pit for even a few hours after it is ready to come out, may spoil it.

The sweating process hastens the expansion of the hide, opens the pores, and brings the hide back to a state analo-

gous to that at the time of slaughter; it gives to the dry, wild hide a much-needed development. During the putrefaction process much ammonia is generated as a result of decomposition. Efforts are being made to isolate the specific germ causing the putrefaction that loosens the hair. If these efforts are crowned with success and an antiseptic is found that will be fatal to germs other than those which cause putrefaction, the sweating process will be greatly simplified.

After sweating, the hides are thrown into water or a weak lime bath, which stops further putrefaction.

15. Warm-Sweat System.—As practiced in Germany, the warm-sweat system consists in placing the folded hides in an air-tight buried box, which is then covered with spent tan. Steam is frequently used to accelerate the sweating process, but its use is attended with great risk; the heat spontaneously generated by the hides is preferable. This system requires even more care than the cold-sweat process, because putrefaction promoted by heat makes rapid progress and may cause great loss.

*If fresh-slaughtered hides are to be depilated by the sweating process, the flesh side must be thoroughly salted and the hides then folded; they are piled one on another and covered with straw. They are taken down after 18 or 20 hours, the hides opened and refolded, and again piled and covered, after which only occasional turning is needed to make the hair begin to slip. In the United States, most of the fresh-salted hides are limed and not sweated.

16. Liming.—The depilation of hides is most commonly accomplished by placing them in a solution of lime until the hair bulb is loosened, when the hair can be readily scraped off. The lime acts on the roots of the hair and the hair sheaths are dissolved, but the hair itself is but slightly altered. Lime also acts on the skin; the fibers swell and absorb water, so that the skins become plump and swollen, and at the same time the substance that glues the fibers together is dissolved

*In the United States the warm-sweat system differs from cold sweat only in regard to the temperature of the sweat pit.

and the skins become a mass of finer fibers. The lime also saponifies the natural fat, or oil, of the skin.

17. Lime vats are made of timber or of masonry and are sunk into the ground so that the tops of the vats are on a level with the floor. The contents of the vats are made up by slaking the desired amount of quicklime and thoroughly plunging the solution. Generally, two or more lime vats of different ages are used, the hides remaining in one vat for a time and then being moved by means of hand reels between the vats, to the next lime vat.

The time required for liming depends on the kind and condition of skins, conditions of the atmosphere, and the temperature of the limes in use.

The question of when to throw away the limes is also an open one. Some tanners use them until they are almost saturated with decomposing matter extracted from previous hides. A lime in this state becomes a depilator by means of putrefaction and not because of its caustic action, but this should not be considered as good practice.

18. Lime in excess must be present in the vats, so that a saturated solution of the hydrate of calcium is always surrounding the hides. Lime in solution is rapidly consumed in the depilation of the hides and must be constantly renewed. Much of the residue of the lime vats, generally mistaken for unused lime, is in reality a mixture of calcium hydroxide and calcium carbonate formed during the liming process. It is, therefore, found practical to add fresh lime from time to time to the vats and by frequent plungings keep it in suspension.

19. Hydrated Lime.—In place of the older method of using lump lime, many tanners now employ the product known as *hydrated* lime. This form of lime is produced by adding just sufficient water to bring about the union between the calcium oxide and water, according to the following reaction

$$CaO+H_2O=Ca(OH)$$

The advantage of this material, which comes to the tanner in the form of a powder packed in bags, is that it may be kept indefinitely without change, and is always uniform in composition and action.

20. Sodium Sulphide.—Sodium sulphide, when dissolved in water and used as a depilating agent, has the property of quickly destroying hair and epidermis. It has the advantage of rapid action and the production of a tight leather, but has at the same time the disadvantage of a tendency to cause a drawn condition of the grain. For certain classes of leather, its use is desirable, in which case a 20° Bk.* solution is prepared in a paddle at a temperature of 70° F. The stock is entered and the paddle run for about 2 hours, when the wheel is stopped and after that it is run for 5 minutes each hour during the remainder of the day. The stock is kept in the liquor overnight and turned from time to time during the morning. At about noon the plug is drawn and the spent liquor discharged. The paddle is filled with water and run for half an hour. One per cent. of sodium bicarbonate is now added and the wheel turned for the same length of time. Fresh water is then turned on and the stock washed in running water for 3 hours.

Sodium sulphide is sometimes used with lime. It forms caustic soda and calcium sulphide when it comes in contact with the lime. The calcium sulphide acts as a solvent for the hair and renders easier the removal of the very fine hair. The use of sodium sulphide shortens the unhairing process and causes less loss of hide substance as compared with lime, but it has the disadvantage of causing brittle, harsh leather unless it is carefully used in comparatively small amounts. The usual custom is to add the sodium sulphide in the first stages of depilation, the amount employed being about 10 per cent. of the lime taken.

21. Sodium Sulphide and Calcium Chloride.—It has been found that a combination of calcium chloride with

*See *Manufacture of Leather,* Part 2.

the sodium sulphide will obviate the danger from drawn grain and the process is carried out as follows: Into the paddle is placed a weighed amount of sodium sulphide sufficient to produce a 20° Bk. solution. To this solution is added 1 pound of calcium chloride for every 4 pounds of sulphide taken. The same method of handling is pursued as for straight sulphide, except that 2 per cent. of sodium bisulphite is used for neutralization in place of sodium bicarbonate.

22. Arsenic sulphide is sometimes used in connection with lime and has the advantage that it does not produce a strong caustic condition. The form of arsenic sulphide employed is that known as realgar, or red sulphide of arsenic, having the formula As_2S_2.

23. Unhairing and Fleshing.—After the liming or sweating operation is completed, the hides are ready to have the loosened hair scraped off and to have the fleshy and fatty matter on the flesh side removed. These operations are known, respectively, as *unhairing* and *fleshing*.

The unhairing and fleshing of hides is done both by hand and by machine. The latter method is superseding the hand method only slowly, because of the care needed in operating the machine. An unskilful or careless operator may spoil hundreds of dollars' worth of hides in a day's work, and the greatest care and judgment must be exercised on the part of the workman while running the machine.

The operations of unhairing and fleshing take place in what is known as the *beam house*. After the hair has been loosened, the hides are brought into the beam house; if the sweat pit has been used to loosen the hair, the hides are placed in cold water, which cools them and interrupts the putrefaction that has set in. Limed stock is generally unhaired without previous washing, being brought directly from the limes to the beam house.

24. The beams on which the hand process of unhairing takes place are convex in shape, one end resting on the ground while the other is about the height of the workman's waist.

Over these sloping beams the hides are spread and by means of a concave knife, the curvature of which conforms to that of the beam, the hair is removed. The operation is fatiguing, and only men of long experience, skill, and considerable strength, are employed.

The knife is pushed against the hair, the sides being worked from the hind shank toward the head and then toward the back. In removing the short, fine hair, hides are occasionally damaged by having the grain cut; to prevent this, a guard that projects beyond the edge of the knife and serves to protect the hide, is sometimes used. After the hair is removed, the hides are placed in water overnight and are then usually ready for fleshing.

25. The operation of fleshing by hand consists in removing the fleshy and fatty matter by means of a sharp knife. The work requires great skill. Both straight and curved knives are used in the operation. The hide is thrown across the beam, which has first been covered by a hide already fleshed. The flesh is removed by long strokes of the knife, held in a slanting position, the right hand being uppermost. A long, steady drive results in fewer accidents to the hide than a short, choppy stroke. After the flesh has been removed from the main body of the hide, the hide is trimmed with a sharp knife and the shreds and projecting filaments are removed. All the fleshings are saved and sold for glue making.

After fleshing, the hides are hung on individual sticks in vats of fresh water. If the hides are to be used for upper leather, the soaking is dispensed with and the hides at once bated.

The hand method of fleshing and unhairing is slow, and has been almost entirely superseded by machines, which, if placed in the hands of skilled operators, do the work for about one-third of the former cost.

26. Machine Fleshing and Unhairing.—With machinery, the hides are fleshed either after soaking and before liming or after they come from the limes. If fleshed before liming, they are generally run through the machine again after

coming from the limes, in order to remove both the flesh left on after the first fleshing and the flesh raised up by the liming process.

The machines that do the beam-house work are heavy, rigid affairs. The removal of the hair and flesh is accomplished by rapidly revolving rolls, having raised irregular spines on their surface.

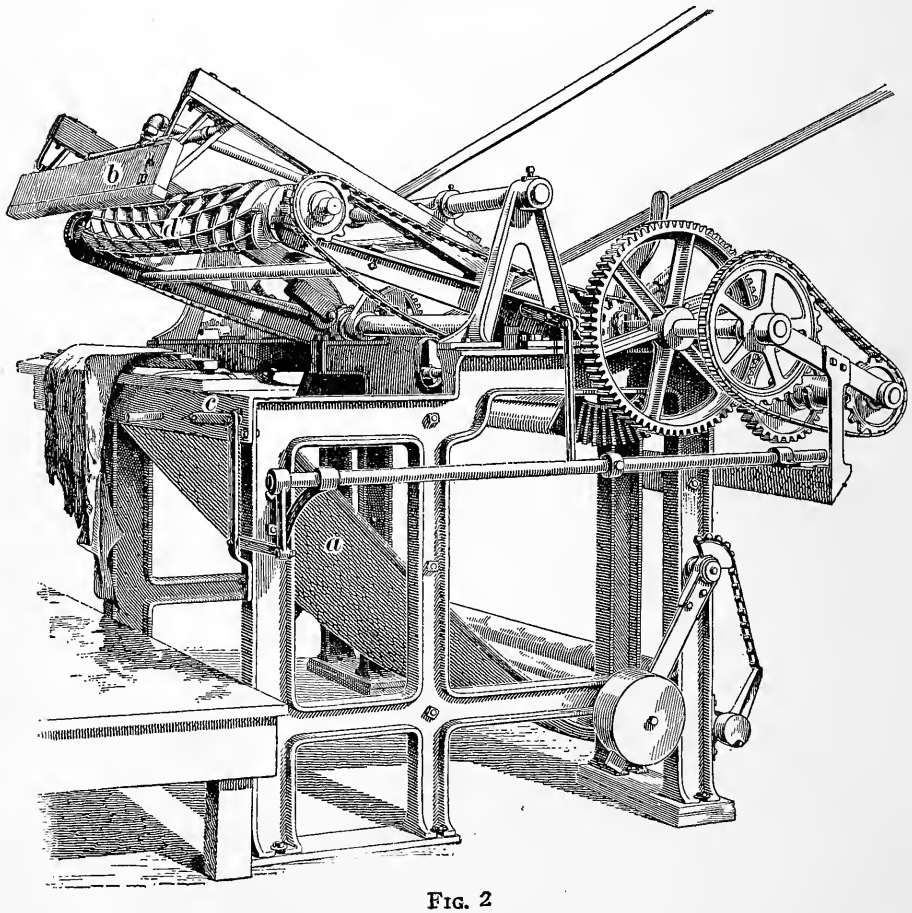


FIG. 2

27. The **Leidgen unhairing machine,** Fig. 2, is an approved machine for unhairing. It consists of a revolving cylinder *d* supported on a steel frame that moves up and down in the arc of a circle, at the will of the operator, over a flexible bolster *a* on which the hide to be dehaired is placed.

The hide or side is thrown flat on the flexible bolster *a*, the holder *b* is brought down and automatically clamps the end of the hide or side. The lever *c* is then thrown so as to put the machine in operation. The cylinder *d*, revolving at the rate of 190 revolutions per minute, moves down and up over the hide spread on the flexible bolster *a*. By reversing the lever, the revolving cylinder may be made to travel up and down within the space of 2 or 3 inches. After the hair is removed from one end of the hide, the holder is released, the position of the hide on the bolster reversed, the holder again brought down and the remainder of the hair removed. Jets of water from a perforated pipe running behind the holder constantly play on the hide while it is being dehaired.

The cylinder *d* is of cast iron, 6 inches in diameter, on the surface of which steel blades are inserted. The cylinder always revolves in the same direction whether passing up or down over the hide. The bolster *a* is securely fixed at the upper end and suspended at an angle of 45°; at the lower end, by a system of weights and levers, an equal tension is produced at all times over the entire surface. Being supported only at the ends, the bolster is perfectly flexible over its entire surface, and the thick and thin parts of the hide are thereby subjected to even pressure. This machine will perform the work of 6 men and, with a skilful operator, there is little danger of damage to the stock.

28. For removing the flesh from the hide, the fleshing machine, shown in Fig. 3, is largely used in the tanneries of the United States. It consists essentially of a spirally bladed fleshing roll *a*, past which the hide is fed by a rubber-covered bed roll *b* working in connection with a pair of fluted steel grip rolls *c* and *d*.

The illustration shows the fleshing machine with grip rolls open, ready to receive the hide or side to be fleshed. The operator inserts the hide flesh side up between the parted rolls. A slight pressure on the treadle *e* causes the grip roll *c* to move down through the circular guides and take its place between the grip roll *d* and the rubber roll *b*. All three rolls

move forward, thus firmly gripping the hide and holding it in the proper position without damaging it. The revolution of the bed roll *b* and grip rolls *c* and *d* pulls the hide between the bed roll and the rapidly revolving fleshing cylinder *a,* which removes the flesh from the hide as it slowly passes under the cylinder. When the fleshing is completed, the treadle *e* is depressed, and while the rubber and front grip rolls are moving

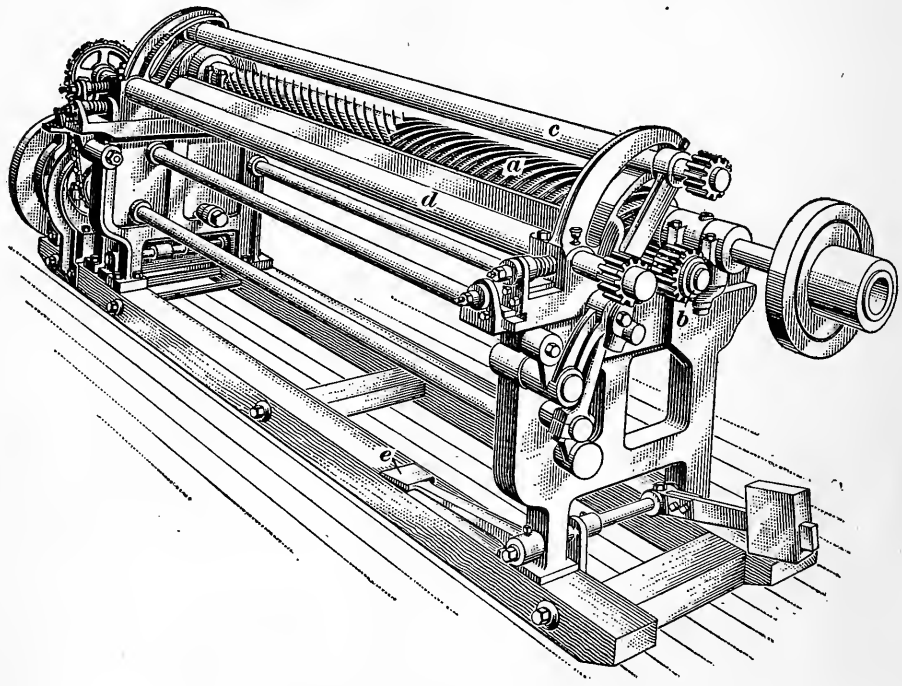


FIG. 3

away from the cylinder the middle grip roll is traveling up and back through the circular guides, and the hide is released. One-half of the hide is fleshed from the center to the end, and is then reversed and the other portion is fleshed. The thick rubber covering of the bed roll, aided by springs on which its bearings are mounted, serves to compensate for varying thicknesses of the stock being worked. Similar springs on the bearings of the front grip roll prevent undue compression of the thick parts of the hide.

29. Deliming.—It is essential that the lime or other depilating agent should be removed after it has done its work.

For sole and belting leather, it is only necessary to remove the depilating agent, but for soft leather the stock should also be brought to an open and flaccid condition, which is accomplished by what is usually spoken of as *bating* and *puering*. These two terms formerly meant two distinct processes, the former term being applied when pigeon or hen manure was used, and the latter when dog manure was employed. Today, however, the term *bating* is most generally used and *puering* only spoken of in connection with the manufacture of goatskin into leather. The use of animal excrement in recent years has been almost entirely replaced by less objectionable materials and that step in the operation placed on a scientific basis.

Ordinary deliming may be accomplished by means of weak organic acids or certain chemicals, while bating, puering, or drenching must be brought about through fermentation, or bacterial or enzyme action. As bating plays only a minor part in the manufacture of heavy leather, its consideration will be postponed until the processes involved in the production of light leather are discussed. Mention should be made, however, at this point, of some of the most important chemical deliming agents.

30. Lactic Acid.—In recent years, lactic acid has come into quite general use as a deliming agent. About 2 pounds of acid are employed for each 100 pounds of stock. This acid not only removes the lime, but, if added to the amount mentioned, has a tendency to plump the hide, which is very desirable in the production of soles.

31. Formic Acid.—Formic acid comes to the tanner as a 60 per cent. solution and is preferred by many on account of the rapidity of the action. Like lactic acid, it is also a strong plumping agent.

32. The common practice in heavy leather is, after fleshing, to wash the stock in running water and then place it in the cold pool over night, when the subsequent operations are carried out.

33. Plumping the Hides.—In making sole leather, where weight is desired, it is advantageous to secure a good degree of plumpness before the hide reaches the liquors that really do the tanning. By **plumping** is meant the swelling of the cells and the distension of the pores of the hide, so that the entrance of the tanning liquor is facilitated. If the hide becomes too plump, hard, brittle leather results; hence, it is very essential that the proper degree of plumpness is attained.

The plumping is done by acids that are either formed in the tan liquors or are added to them. The natural acids formed in a vegetable tan liquor are mostly lactic and acetic. All of them are of fermentative origin, formed by the decomposition of the sugars constituting a part of the non-tannins of the bark. The absence of the requisite amounts of non-tannins in the liquors will thus cause a scant supply of plumping acids. For this reason, several so-called *sweet tanning agents* are unfitted for tanning heavy leathers, unless they are mixed with other liquors rich in non-tannins.

Quebracho extract is a liquor in which the proportion of the tannins to the non-tannins is so great that acid is slowly formed, and a quick tannage is secured but the leather is not well filled or nourished. If quebracho is mixed with some liquor with a large non-tannin content, this difficulty is removed. The extracts made from oak or chestnut woods are great acid makers because of their high percentage of non-tannins.

34. Methods of Obtaining Plumping Acids.—In a well-regulated bark yard, the acid formed will be in the proper proportion to the tannin in the liquor, and there is no need of the addition of plumping agents. It sometimes happens, during the cold seasons of the year or when a yard is starting up after an extended shutdown, that the acid is deficient.

Various methods are employed in order to help the formation or increase the supply of acid. Crude molasses is sometimes added; a mixture of old cheese, molasses, or glucose, and some substance containing nitrogen, as ammonium nitrate, will stimulate the production of lactic acid. Commercial lactic, acetic, and formic acids are all used for plumping purposes.

The increasing percentage of extracts used for tanning is gradually causing the tanner to provide means for the development of acid in his yard, and eventually in every tannery the plumping acid will have to be added to the liquors in the form of organic acids, or *grown* in the liquors by the addition of ferments, or by the use of acid-forming tanning materials.

35. It sometimes happens that too much acid is formed in the yard. The reason for this is not easily determined. It may be due to the season or the weather; it may be caused by the method of leaching, the nature of the water supply, or it may be due to other causes seemingly too insignificant to produce such an effect. A tannery where the bark is closely leached will have more acid in the yard than the tannery where there is less regard for economical practices in the leach house. A very soft water or a peaty water will help acid production.

A yard with too much acid is harder to handle than a yard with too little acid. It requires close watching to prevent the production of hard leather inclined to crack and a consequent heavy financial loss. This condition of the yard may be only temporary, or it may be a permanent one. In correcting too great acidity, the *handlers,* or *rockers,* that first receive the green stock should receive the first treatment. Dilution with weak sweet liquor, or even with water, will help their condition. Sodium carbonate added to them will, of course, neutralize the acid, and soften the leather hardened by the excess of acid; but care must be taken as to the amount added, for too much sodium carbonate will make the stock too soft.

The addition of an antiseptic, as corrosive sublimate or carbolic acid, will stop the formation of acid, but will not lessen its amount. The former is the better antiseptic to use, as carbolic acid sometimes tends to darken and spot the leather. Since the antiseptics do not decrease the amount of actual acid present, they are best used in the yard vats to retard the development of acid in that quarter.

36. In a properly managed sole-leather yard, where bark liquors are used, deficiency or excess of acid is unusual. Some tanners pay no attention to this matter, depending on acids introduced into the first liquors for plumping. Commercial acetic and lactic acids are commonly used, and while they accomplish the end for which they are put in, they are unnecessary in a sole-leather yard, where natural means will generally furnish the acid required.

Where the commercial acids are used, continual vigilance must be exercised in paying attention to their strength and the amounts to be used; otherwise, the hides will not be uniformly plumped and the leather will show a corresponding non-uniformity of texture and fineness. With certain classes of hides used in making a special class of sole leather, sulphuric acid is used for plumping. The use of this agent will be discussed in the description of the manufacture of this leather.

37. The plumping is done in *handlers,* or *rockers,* which are vats containing liquors that have been weakened by usage and are well soured. The acids present effect the plumping, and the small quantity of tannin in the liquors serves partly to tan the exterior portions of the hides. To equalize the action of the liquors in these vats, the hides are handled, or rocked, so that all portions of the hide come in contact with the liquor, and the liquor itself is constantly in motion.

The handlers, or rockers, are generally arranged in sets of a number of vats varying in strength. In handling the hides, it was formerly the custom to lift each hide from the vat and throw it into the next vat in the set, this process continuing through all the vats in the set. It is customary now to tie the hides one to the other, and by means of a hand reel the continuous string of hides is moved from one vat to the other. The *hand reel* is a wooden-stripped cylinder mounted on a stand about 4 feet high and turned by means of a crank. In operation, the reel is placed between two vats, one man turning the crank while another starts the string of hides over the reel and then arranges them in the vat that receives them, the friction of the hides on the reel carrying them along.

Handling by rockers is done by means of a wooden frame hung by pivots in the center of the top of the vats, so as to give a dipping movement of 6 to 8 inches to each end of the frame. The hides are hung over sticks placed across the frame. Motion is imparted to the frames of the rockers by beams connected with overhead shafting. By this means all parts of the hide are kept in contact with the liquor which is well agitated. This end is also attained in some tanneries by hanging the hides in the vats and agitating the liquor by means of an air pump, which supplies air to the bottom of the vat. The air bubbling up through the liquor keeps it in motion.

SOLE-LEATHER MANUFACTURE

38. Methods of Tanning.—The simplest and most typical methods of tanning are those used in making sole leather. The tanning of other bark-tanned leathers is accomplished mainly by variations of these methods. For this reason, a discussion of the various processes of tanning in the manufacture of sole leather will precede the description of processes for the tanning of the skins used in the production of more delicate leathers.

The system at present pursued in the tannage of sole leather is the result of an evolutionary process depending on the selective ability of the tanners themselves. Few scientific discoveries have helped them, and the basic principles of their art have only recently received attention. This state of things is due to several causes: In the first place, in an art that has attained a high degree of perfection through the endeavors of generations of practical workers, we are apt to rest with the results achieved without questioning the principles involved. In the second place, the raw materials, hide and tannin, being organic bodies of an unknown, or at least of a very complex, nature, there was limited foundation for theories of their natural interactions until more knowledge of them was obtained. The field for applied research is very promising, however, and much has been done

in recent years to place this branch of the industry on a scientific basis.

39. Sole leather is always sold by weight, and the cost of the hide is from 50 to 70 per cent. of that of the finished product. The object of the tanner is to make as many pounds of leather from a given weight of hides as he can possibly produce. His degree of success in this is technically known as *gain*. In the case of green-salted hides, a large percentage of the hide, as it is bought, consists of water and salt and such impurities as dirt, dung, and blood, so that 100 pounds of green-salted hides will only make from 60 to 80 pounds of finished leather. The gain would be spoken of as a gain of from 60 to 80. Dry hides contain practically nothing but dried hide substance, and 100 pounds of this class of hides will make from 150 to 185 pounds of leather, the gain in this case being a gain of from 50 to 85.

With green hides, the gain is the amount of leather made from 100 pounds of hides; with dry hides, the gain is the amount of leather made from 100 pounds of hides, less 100.

40. Vegetable tannage is to a certain extent, no doubt, a chemical process, but after the final chemical reaction between the hide and the tannin has taken place, the product is capable of a further absorption of tannin; the point at which chemical reaction ends and physical absorption begins, has not been determined. Suffice it to say, that sole leather may contain from 20 to 50 per cent. of tannin, and yet in all cases it may be thoroughly cured and perfectly tanned. There is, however, a minimum limit at which hide treated with tannin is leather, and this limit is the satisfaction of the purely chemical affinity of the hide for tannin.

The whole process is an economical one; the tannin does not change materially while in solution, and it is almost completely recovered from the tan liquors by the hide during the process of tanning. With vegetable tannage, labor costs are low, the only disadvantage being the time consumed and consequent loss of interest on the money invested in the process.

41. There are three general varieties of sole leather made in the United States, the names given them indicating the bark used in tanning. They are *oak, hemlock,* and a combination of both, known as *union.* Each of these classes of leather has special modifications represented by special grades of leather. The greater part of the sole leather made in the United States is tanned by hemlock bark. European prejudice against this leather has been removed and immense quantities are annually exported. Hemlock leather is produced by two methods of tanning—*acid* and *non-acid.* Some *slaughter hemlock* is also made, but this forms only a small percentage of the output.

42. Oak Leather.—Leather made from hides tanned with oak bark is distinguished by its color and texture. Oak bark gives a deposit, or *bloom,* of ellagic-tannic acid on the leather, and oak leather is known as *scoured* or *Texas,* depending on the removal of this bloom.

The hides used are green and generally of native slaughter. The Texas hides are usually from range cattle, and are made mostly into unscoured leather; those hides which are not branded or have only small brands are used for scoured leather. South American hides make a good grained scoured leather and are in demand for men's shoes of the highest grade.

The hides are placed in the soaks for about 3 days, but the time may be shortened by using warm water and a loss in hide substance saved thereby. The water in the soaks is changed with each pack of hides. Some tanners remove the hides after the first day's soaking and replace the dirty water with fresh.

The hides may be fleshed after soaking or they may be put in the limes and the fleshing and unhairing done after they leave the limes. Different tanners have different methods of liming this class of hides. Some leave them in the limes as long as 5 days, while others complete the liming in 2 days, handling the hides continually and using a lime-sulphide mixture. It is claimed that a warm bath of, say, 100° to 110° F. given to the hides the night previous to unhairing, is beneficial.

After soaking, the hides may be split along the spine line into two sides, or the splitting may not occur until after liming, and in some tanneries the whole hide is tanned.

After unhairing and fleshing, it is the custom in some tanneries to bate the stock. With the amount of acid usually present in an oak tannery, however, this is unnecessary and is the exception rather than the rule. The hides are usually placed in a vat of clear water and permitted to remain there overnight. The hides are then suspended in the *rockers,* and the real tanning begins.

43. The rocker vats are in complete sections, piped so that liquor from the bottom of one vat is delivered to the top of the next. As liquor is supplied to the head, or strongest, rocker vat, it gradually works around through all the vats, being weakened in each by the presence of the hides, until it reaches the weakest, or tail-rocker, vat, from which it flows to waste. The stock is hung in this tail-rocker vat, and is here constantly rocked in contact with the liquor coming from the next vat, which gradually becomes stronger until it is receiving the strongest liquor and has become the head-rocker; the stock is then removed and is ready for the lay-away vats.

The object to be attained with the rocker liquors is the removal of the lime remaining in the grain (it being neutralized by the organic acids in the liquor), the swelling of the hide, and the setting of the color. The quality of the leather is determined by the work done in the rockers and handlers, according as the plumping, coloring, etc., is properly done.

The liquor used in the rockers should be old, mellow, and not strong. The strength of the liquor is regulated by the number of pits in use, so that the green hides should have sufficient acid to purge them of lime and properly start the plumping.

44. From the rockers the hides are taken to the main tanning yard, where the lay-away vats are located. These vats are generally 9 feet long, 7 feet wide, and $5\frac{1}{2}$ feet deep. In these, the hides are laid out flat, one by one, and a thin layer of ground oak bark sprinkled over each hide. This bark should not be ground too fine, or the weight of the pack will

cause the hides to settle together too much and the circulation of the liquor will be prevented, thereby destroying one of the purposes of the bark, and ultimately resulting in imperfectly tanned leather. Each layer is treated in the same way, fresh tan or bark being used in each case.

After laying away has begun, the tanning is conducted on lines peculiar to the individual tanner. Each man has his own ideas as to how much liquor the hide should receive and under what conditions. In general, the hides are allowed to remain in a lay-away until the liquor in that vat is sapped. The hides are then removed, the liquor run off, and stronger liquor used after repacking the hides, as before.

TABLE I

LAYER SCHEDULE FOR OAK-BARK TANNING

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First	8	34	4.00
Second	12	38	4.25
Third	16	38	4.25
Fourth	25	40	4.75
Fifth	32	48	5.75

Each pack of hides is laid away from four to seven times, according to the theories and judgment of different tanners, the whole operation of laying away extending over a period of from 3 to 5 months. These successive lay-aways are called *layers* and are known as first, second, third, etc., layers, according as they represent the first, second, or third lay-away that the hides have received.

45. Tanners differ not only as to the number of layers that oak leather should receive, but also regarding the temperature and strength of the liquor on these layers. For example, the schedule shown in Table I is in effect in a large tannery where oak-bark tanning is employed.

46. In another successful tannery where the oak-bark tanning process is used, six and sometimes seven layers are given. The temperatures of the various layers are also kept well up, and if it is necessary to tan the hides in a shorter period, these increased temperatures, with proper regard for the strength of the liquors, will produce the desired effect. Only a few years have elapsed since the use of warm liquors in the yard was inaugurated, and they have not been well received by all tanners. The schedule followed in this yard is given in Table II.

TABLE II

LAYER SCHEDULE FOR OAK-BARK TANNING WITH WARM LIQUORS

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First	8	34	70	4.35
Second	11	38	75	5.00
Third	16	35	80	4.60
Fourth	25	40	90	5.15
Fifth	34	44	100	5.80
Sixth	48	50	110	6.40

The time taken for tanning by this schedule is a little longer than by the first one given, but the leather seems to be of a closer texture, better filled, and of better wear-resisting qualities.

The first-layer liquor in this yard is an old liquor—the sapped fifth layer—and the second-layer liquor is also an old liquor—the sapped sixth layer. The other liquors are new, sweet liquors made by strengthening oak-bark liquors with chestnut-wood extract.

47. Oiling and Drying the Leathers.—When the tanning is complete, the sides are taken from the last layer and thrown into warm water to clean the grain of sediment

or fine particles of bark. After rinsing, the sides are piled to drain overnight. They are then swabbed with cod oil, or a mixture of cod and other fish oils, or a mixture of mineral oil and fish oils. The swab used is a piece of sheepskin tanned with the wool on. The sides are then hung on sticks or by brass catches in the drying loft.

48. The drying loft is generally located over the vat yard; steam pipes are spread over the loft floor and rest on blocks that support the pipes and allow air to circulate around them. A slat-work floor over the pipes serves as the floor of the loft. Tight windows and ventilators are provided so that the proper adjustment of light and ventilation can be maintained. In some tanneries, the heat and ventilation are supplied by mechanical means, blowers carrying air to the loft and keeping the atmosphere in constant circulation. Without proper circulation the air becomes stagnant among the closely hung leather and the damp leather will become moldy. To aid in keeping the air in circulation, openings that may be regulated as to size are generally distributed around the floor of the loft. The same end may also be attained by forcing air into the loft at a pressure slightly above that of the atmosphere, thus effectually moving any stagnant air.

The leather is hung over poles whose ends rest on beams, or it may be held by an ingenious brass device in which the weight of the side causes friction to uphold it.

49. Rolling the Leather.—When thoroughly dry, the sides are taken from the drying loft to the rolling room and there brushed with water and made into covered piles. When properly tempered, the sides are oiled on the grain side, rolled and dried in the loft, and, when dry, are sorted for the market. The rolling of the leather serves to smooth the grain side and compress the leather, thus making it firmer. It also puts somewhat of a polish on the finished leather. Rolling is effected by machinery.

50. The **leather roller** is a machine consisting of a heavy beam having on its end a polished brass wheel. This

wheel is about 8 inches in diameter and has a 6-inch face. A crank gives to the beam a direct motion, allowing the brass wheel to move about 1 foot each way right and left. The leather is held under the moving wheel, or roller, on a small bed of brass conforming to the arc described by the roller. A foot-lever serves to raise this bed and makes the pressure of the moving roller light or heavy, according to the will of the operator. By moving the leather around under the roller, all parts of it are finally smoothed and polished.

51. In some tanneries, the vat sizes of which necessitate it, the hides are split into sides as they come out of the soaks or out of the limes. Whole-hide tannage is more economical as to labor costs in the yard, but side tannage is more economical in beam-house work.

A large, light-colored, and even deposit of bloom on oak leather is considered a mark of fine tannage; for some purposes, the leather is sold with the bloom removed and is then known as *scoured leather*. For this leather, the hides are split and rinsed as usual. Then they are scoured by the scouring machine, drained, oiled, and dried. After this, they are dipped in water, rolled, and dried, and then receive a final rolling before going to the sorting room.

52. Most of the old-style oak sole leather is made from hides tanned in the manner just mentioned; but a considerable amount of so-called oak leather is also sold that is tanned with oak bark and chestnut-wood extract by methods similar to those used for tanning non-acid hemlock and union crop leather. The leather is bleached, and it is oiled in the wheel instead of by hand; and, except in the matter of tanning materials used, the process of tanning is quite different from true oak tanning.

53. Non-Acid Hemlock Tanning.—In the non-acid hemlock process of tanning, the hides are swelled, or plumped, by the natural ferment acids in the tan liquors, while in the acid process, a solution of sulphuric acid is used to effect the plumping.

54. Treatment of the Hides.—With the non-acid hemlock process, the hides used are generally dried South- or Central-American skins. They are well soaked and softened with the help of the hide mill. It is the usual practice to soak the hides from 5 to 8 days; then they are milled and thrown back into water for another shorter period. They are then milled again and may receive another day's soaking before the tanner considers them soft enough for good results. After soaking, they are split along the spine line into sides, and the hair is removed by either sweating or liming. After the removal of the hair and fleshing, the sides are soaked overnight in water and are then ready for the handlers. Limed stock is bated in some tanneries, a light bran or hen-manure bate being used. Before putting it in the handlers, some tanners *color* the stock by running it for a few minutes in a paddle wheel revolving in a vat of acid spent liquor of from 8° to 12° Bk.

55. The sides are strung together for handling by tying a shank of one to the shank of the next, and the string of hides is then dropped into the tail, or weakest, handler vat. The handler vats are arranged in continuous sections that are so connected that liquor run into the head vat passes successively through the other vats in the section, flowing from the top of one vat to the bottom of the next. Hand or power reels are placed between each pair of vats so that the string of sides may be easily moved from one vat to the other. The handler liquors are sapped liquor, generally from the first three layers of the lay-away yard; they are weak in tannin and contain the natural plumping acids. The head, or strongest, handler liquors are generally from 14° to 18° Bk., and are sapped by the green stock until the tail, or weakest, handler liquor becomes of a gravity not much above 8° Bk. The strength of the handler liquors depends on the strength of the lay-away yard, which is controlled by the method of the tanner in charge. The stock is put into the tail-handlers and reeled forwards and backwards, perhaps every hour during the first 24 hours, and possibly eight or ten times during the sec-

ond day. This reeling serves to change the position of the stock as it lies in the liquor, plunges the liquor, brings every part of the hide in contact with the liquor, and equalizes the effect of the tannin and color on the green stock. After the first 2 or 3 days in the handler liquor, the stock is reeled forwards once every day into a stronger vat until the head-handler or strongest handler is reached; and, the handler liquors having accomplished the plumping and started the tanning, the strings are removed and the stock goes to the lay-away yard. Here, the stock receives from five to seven layers in liquors of different strength, according to the methods in use at the tannery.

56. A schedule in use at a successful non-acid tannery is given in Table III.

TABLE III

LAYER SCHEDULE FOR NON-ACID TANNING

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First	7	21	2.85
Second	11	22	3.40
Third	12	23	3.60
Fourth	18	24	3.75
Fifth	19	28	4.00
Sixth	26	28	4.00

In this tannery the liquors are used at a temperature of from 70° to 75° F. on all the layers. The first layer is an old liquor that has been sapped by usage on the fifth layer, and the second-layer liquor is also old, having been sapped on the sixth layer. The third-, fourth-, fifth-, and sixth-layer liquors are all sweet liquors made by strengthening leach-house liquor with extract. The sapped liquors from the first, second, and third layers are used as handler liquors; the fourth layer

sapped is returned to the leach house, and the fifth and sixth layers sapped, as just explained, are used for first- and second-layer new liquors, respectively.

The hides are kept in the first-layer liquor for the required number of days. The pack is then hoisted, the old liquor removed for handler purposes, and the hides placed in the second layer. This process of treating the skins to successively stronger tanning liquors goes on until the last layer is reached. The leather is then finished so far as actual tanning is concerned. The length of time for each layer is a matter determined by the judgment of the tanner, and therefore differs with conditions. Theoretically, it would be best to allow a pack of hides to remain in a layer until there was no more sappage, or taking up, of tannin by the hides. After the tannin contents of hide and liquor are equal, months of further contact will not put any more tannin in the hide in that layer.

TABLE IV

LAYER SCHEDULE FOR NON-ACID TANNING WITH WARM LIQUORS

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First	5	28	70	3.15
Second	12	30	80	3.40
Third	14	32	85	3.60
Fourth	18	34	90	4.00
Fifth	20	38	100	4.75
Sixth	24	40	110	5.00

57. Use of Warm Liquors.—There is some prejudice against the use of warm liquors in a tan yard, but if the proper limit of heat is not passed, the results seem to be beneficial. By the use of warm liquors, the length of time on the first layers is shortened and stronger liquors used. In one tannery where warm liquors are used, six layers of liquor are given

to the stock. The schedule of this tannery is shown in Table IV.

The liquors at this tannery are made up as follows: The first-layer new liquor is the sapped liquor from the fifth layer; the second-layer new liquor is made by taking equal portions of the sixth-layer sapped liquor and liquor from the leach house. The third-, fourth-, fifth-, and sixth-layer new liquors are made by strengthening leach-house liquors with chestnut-wood extract.

The temperatures on the different layers are adhered to within a range of 5 degrees either way. With these warm liquors, the duration of the tanning process may be shortened, but an increased period does not harm the stock.

With the old process of tanning, the leather, after coming out of the last layer, is thrown into a pool of water to remove the sediment that has accumulated on the surface of the leather. This is also frequently accomplished by placing the leather in a drum with water and revolving it for a few minutes.

58. Bleaching.—After the rinsing process, the leather is piled to drain and then bleached. The bleaching to which sole leather is usually subjected is not really a bleaching process, because the excess of tannin on the surface of the leather, which lightens the color of the stock and also makes it less liable to crack, is simply dissolved and removed. The bleaching consists in dipping the leather into an alkaline bath that dissolves and removes the excess tannin, then into an acid bath that neutralizes any soda remaining on the leather, and finally into water to remove the remaining acid. For convenience in handling the leather, the three vats are placed in a row, and the leather, hung on sticks supported on a frame, goes into one vat for the desired time. Then, the frame is raised and the leather drained, after which it is put into the next vat. This process is continued until the bleaching is completed. The time necessary for the reaction that takes places in each bath is utilized by the workman in unloading a frame of bleached leather and in loading a frame of leather ready to be bleached.

Sodium carbonate, as sal soda or as soda ash, is the alkali generally used, because it is the cheapest; and, for the same reason, sulphuric acid is the acid always used. The tanner regulates the strength of the bleach by varying the quantity of soda ash or sal soda (and accordingly the acid), the strength depending on the color desired.

59. After bleaching, the leather is hung or piled to drain and to dry off slightly before oiling. Hand oiling is now rarely employed, the majority of tanners applying the oil in the oil wheel. The oil wheel is simply a revolving wooden drum fitted with a removable door, and hollow axles through which the oil is pumped. The oil used is either cod oil, winter-pressed fish oil, or mineral oil, or mixtures of these oils. Many tanners adhere to the use of cod oil, but a good grade of fish oil from which the sediment has been removed by pressing while chilled—or what is known as winter-pressed oil—will give the same results as cod oil and is cheaper. The mineral oil is cheaper than either fish or cod oil and gives satisfactory results when mixed with higher-priced oils.

60. The color of sole leather is one factor that determines its market price, and although it seems the height of folly to demand a qualification that does not affect the quality of a product, yet the extent to which this demand for a good color has been carried has resulted in recourse to means of supplying the demand. In the hands of some tanners, these means have been used for the accomplishment of an end other than the one originally intended, and as a result, there is considerable cry about the adulteration of American sole leather. Leather dried in the rough, unless so heavily bleached as to remove too much of its weight, is liable to become dark at certain points on the side. The addition of a small amount of a mixture of glucose, or grape sugar, and sulphate of either magnesium or sodium, to the leather, serves to overcome this tendency and results in a leather that dries easily and finishes bright. In addition to these benefits, the leather thus treated will have firmer flanks and bellies, and it remains in better physical condition, so that it can be cut and worked more readily. The

amounts of the materials necessary to produce these results in a side of leather are so small that their use for this purpose cannot be called an adulteration. The ease with which these materials can be added, however, has, of course, resulted in the production of some cheap, adulterated leather.

61. The glucose and salts are generally added with the oil in the oil wheel. When the leather is in the proper condition for oiling, it is thrown into the oil wheel and $\frac{1}{4}$ pound of Epsom or Glauber salts and $\frac{1}{2}$ pound of glucose for each side, are also thrown in. The door is then put on and clamped, the oil pumped in through the hollow axle, and the wheel revolved from 30 to 60 minutes. At the end of this time, the revolving wheel has caused the tumbling leather it contains to absorb oil and other materials added, and the leather is removed on trucks to the dry loft, where it is hung on sticks and dried.

For the first day or so after lofting the leather, drying progresses without steam or light, but with proper ventilation. The temperature of the loft is then gradually raised until the drying is complete. This process requires from 10 to 25 days, depending on weather and local loft conditions.

After the leather is thoroughly dried, it is taken down, dipped into warm water, and piled down to *sammie,* or to equalize, for 1 to 2 days. Warm water is then sprinkled on the grain side, care being taken that every portion is wet. Then the leather is swabbed with cod or other fish oil, after which it goes to the rollers for a first rolling. After the first rolling, the leather may be hung and thoroughly dried before the second rolling, or it may be piled and second-rolled while in a comparatively wet condition. After second rolling, the leather is hung by one end in the finished-leather loft and, when dry, is sorted and graded for market.

62. Wheeling or Extracting.—In most of the tanneries of the present, the time of tanning in the yard has been materially shortened and the weight that the hide does not receive in the yard is given it by *wheeling* with the tanning solutions. The wheels used for this purpose are from 8 to 10 feet in

diameter and from 5 to 6 feet wide; they are mounted on trunnions and revolved on a horizontal axis by a pinion geared to teeth set around the perimeter of the wheel. A removable tight door secured by clamps provides for the loading and unloading of the wheel, and tannin solution is pumped into the wheel through its hollow axle.

The methods of wheeling and methods of actual tanning vary to the same extent. Each tanner has his own ideas as to the treatment of the stock before and after wheeling, as to the amount, temperature, character, and strength of the tanning solution, and as to the duration of the wheeling. The character, size, and the condition of the leather all determine the kind of treatment to be used, and the tanner's experience tells him what treatment will produce the best results under given conditions.

63. After the yard tanning is complete, the leather is thrown into water to wash off any adhering sediment, and it is then hooked out and goes to the *wringer,* which is a mammoth clothes wringer provided with felt-covered brass rolls. The leather is fed into the wringer and comes out with the excess of moisture removed. As the sides of stock come from the wringer, they are piled on trucks, taken to the wheels, and thrown in. The door is put on, clamped in place, and the wheeling materials pumped into the wheel. The materials used include all kinds of tanning liquors, such as chestnut wood, oak bark, hemlock bark, quebracho, sumac, quercitron, and other liquors, varying in strength from 100° Bk. to the undiluted extract running from 42° to 50° Twaddell (210° to 250° Bk.). The temperature at which these materials are used varies from 100° to 160° F., according to the practice of the tanner. After the leather and wheeling material have been put into the wheel, the power is applied and the wheel makes from 15 to 20 revolutions per minute, the speed varying according to the diameter. The revolution causes the leather to roll and fall within the wheel, and, being in constant contact with the tanning solution, the latter is mechanically absorbed and incorporated into the leather.

64. The completeness with which the wheeling material is absorbed depends on the character, size, and condition of the stock, and obviously on the amount of solution added to the wheel. The amount varies from a quantity of solution that represents 1 pound of solids to the side to a quantity representing 4 pounds to the side. The duration of the wheeling varies from 45 minutes to 2 hours, and on the expiration of the required time, the wheel is stopped, the door removed, and the contents of the wheel removed to a truck. From the wheel, the stock may be piled in low, covered piles, it may be hung over sticks in a dark, cool place, or it may be laid away in strong-liquor vats. This treatment is for the purpose of allowing the mechanically added material to permeate the leather thoroughly and uniformly. After piling, hanging, or laying away the stock for the desired period, it is taken to the bleach room. From this point until the leather is finished, the operations are the same as for leather that has not been wheeled.

65. Acid Hemlock Leather.—By acid hemlock leather is meant a variety of hemlock sole leather that has been plumped by means of sulphuric acid. Other kinds of sole leather are made from hides that are plumped by organic acids, which are either naturally present in the liquors or have been added to them. The sulphuric acid causes an abnormal distension of the pores and swelling of the tissues.

Most of the acid hemlock leather is made from dried hides; that which is made from green hides is known as *slaughter hemlock sole*. The process of manufacture is the same, except that the hides, being green, are generally depilated by means of lime instead of by sweating. The dried hides are largely of South American or of Asiatic origin, this being a very popular method of tanning the Chinese *Buffalo* hides.

The hides are soaked, limed or sweated, depilated, and fleshed in the usual manner and then soaked in clear water. After this they go into a weak tanning liquor. This liquor exerts its slightly astringent effect on the hides, and they are somewhat colored by the bath.

66. Plumping With Sulphuric Acid.—After the treatment just mentioned, the hides are put into a .1 to .3 per cent. solution of sulphuric acid and kept there until the swelling has progressed to the desired stage. They are then ready for the tan yard.

Because of the abnormal plumping by the sulphuric acid, the hides can safely be put into strong liquors. In the other processes of sole-leather tanning, the hides receive weak-liquor treatment, the strength being gradually raised until the maximum is attained. In this branch of the industry, there are no true rockers, or handlers. The only tannin treatment they receive before going to the first-layer liquor is the slight coloring from the weak tanning solution before plumping.

After plumping, the hides go to the first-layer liquors for the time required for this layer. The first-layer liquor in an acid tannery soon becomes impregnated with sulphuric acid and sulphates, and must then be discarded. The free sulphuric-acid content is generally not very high in this liquor, but there is sufficient to interfere with the tanning action. The liquors become very dense and the proportion of tannin to the total solids is low, so that there is little sappage to be obtained. The gravity of this first-layer sapped, or *run-to-creek,* liquor is from 18° to 25° Bk. and it will contain from .8 to 1.5 per cent. of tannin.

A great deal of thought has been spent in trying to devise some method of saving the tannin and to avoid the necessity of running this strong filth-bearing liquor into, and thus contaminating, a stream. The removal of the sulphates by precipitation with barium chloride and subsequent settling has also been proposed. In some tanneries, the practice is to run this liquor over a spent leach of tan bark; this process removes the free acid as well as some of the solid impurities.

67. As in the case of the other sole-leather tanning processes, there are various systems in use in this branch of the industry. There is a little more latitude here, however, than in oak or non-acid hemlock tanning, the first-layer liquor being used in many strengths by different tanners. The liquors

are made by combining bark and extract liquors according to the latest practice of all sole-leather tanners; from five to seven layers of liquors are used, either cold or warm. A schedule of strengths in a cold-liquor tannery is given in Table V.

The first-layer liquor is a sixth-layer liquor that has been sapped by a tanned pack. All the other liquors are made from leach-house liquor or leach-house liquor strengthened

TABLE V

LAYER SCHEDULE FOR ACID HEMLOCK TANNING WITH COLD LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First	8	38	3.60
Second	11	40	3.90
Third	15	42	4.20
Fourth	24	42	4.50
Fifth	24	44	5.00
Sixth	27	48	5.40

with chestnut-wood extract. The sapped first-layer liquor is run to waste, and the other sapped liquors (with the exception of the sixth layer) are returned to the leach house.

68. In Table VI is given the schedule followed in a warm-liquor tannery using seven layers of liquors.

In this tannery, the first-layer liquor is a sixth-layer liquor that has been sapped, the second layer is a seventh-layer liquor that has been sapped, while the other liquors are leach-house liquors made by building up all sap liquors but the first and seventh, which are run to waste and to first-layer new, respectively.

After the leather has been tanned in the yard, it is further treated by the methods described under the head of Non-Acid Hemlock Tanning.

69. Acid slaughter sole leather is made from green hides, the hair being removed by either liming or sweating. When the hides are limed, a bate is sometimes used in the production of this variety of leather, but otherwise the liquors and operations are the same as in the manufacture of the regular acid hemlock leather. The use of sulphuric acid as a plumping agent results in the production of a firmer leather. The action of the acid is much more energetic on sweated hides than on limed stock, because in the limed-stock treatment, part of the acid is neutralized. Therefore, in the regular acid process, care must be observed as to the degree of plumpness attained.

TABLE VI

LAYER SCHEDULE FOR ACID HEMLOCK TANNING WITH WARM LIQUOR

Layer	Strength of Liquor Degrees Barkometer	Time in Layer Days	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First	7	27	65	2.50
Second	9	29	75	2.80
Third	12	30	85	3.00
Fourth	13	32	90	3.20
Fifth	15	34	100	3.40
Sixth	19	34	105	3.80
Seventh ...	28	36	110	4.10

70. Union Leather.—The combination of hemlock and oak barks gives a very serviceable leather known as *union sole leather,* which has a better texture than hemlock-tanned leather, is tougher, and has a color somewhat like that of oak-tanned leather. There is probably more variation in the processes of making this leather than in making other kinds of sole leather.

Color is all-important, and many methods for its improvements are being used. Some go back to the leach house to aid color, and sacrifice tannin there in order to have very pure

liquors, which will give the leather a bright, clean shade. An illustration of the wide difference in union methods may be seen in the fact that in some union tanneries the first-layer liquors are as low as 8° Bk., while in others they run as high as 25° Bk. These liquors are, however, not of the same purity. The 8° liquor will show a higher proportion of tannin to the total solids than the 25° liquor, but, aside from this, the tannin strength of the 25° liquor is greater than that of 8° liquor. In tanneries where strong liquors are employed, considerable oak or chestnut-oak extract is used, the upper layers being strengthened, and the texture and color improved thereby.

71. Most of the union leather made is cropped; that is, the bellies and shanks are cut from the sides, making the product rectangular. The crop leather thus made commands a higher price than union side leather, because much waste is avoided when it is cut into soles. The bellies, shanks, etc. are sold for scrap leather for inner soling, etc. A good quality of cut soles is made from union leather, and the method of selling these cut soles determines the method of tannage in some tanneries. A certain number of soles will be cut from several tannages of leather, and the leather that will give the largest number of soles to a given weight of leather is generally the best seller, if other considerations, as color, firmness, and texture, are equal. This causes tanners to endeavor to produce a light crop leather of a good color, strength, and closeness of texture. These qualities can be obtained by the use of very pure liquors of low barkometer degree. Since purity of the liquor is secured at the expense of leaching, it is really questionable whether this method of tanning pays. More leather can be made from a ton of bark by this process, but the actual gains will not be so great as when a heavy, well-filled leather is produced.

72. Green-salted hides are used for making union leather. They are well soaked, limed, unhaired, fleshed, and placed in clear water overnight, after which the hides go into the rockers. According to the method of tanning in use, the

rocker liquor and all other liquors vary in strength. After coming from the rockers, the leather is cropped in some tanneries, while in others it is tanned and finished as side leather and then cropped. When cropped out of the rockers, the heads and bellies are strung together and thrown on top of the regular leather in the lay-away vats. From the rockers, the sides go into the lay-away yard; from five to seven layers are given, using oak bark on every layer. The oak bark is ground fine, but not fine enough to prevent the circulation of liquor between the sides in the vats. After use in the lay-aways, the bark is sent to the leach house and leached with the hemlock bark for the union liquors. It is generally placed on the bottom of a leach, the hemlock bark being run in on top of it.

TABLE VII

LAYER SCHEDULE FOR UNION TANNING WITH COLD LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First	6	14	2.25
Second	10	16	2.50
Third	10	18	2.75
Fourth	12	20	3.25
Fifth	15	23	3.75
Sixth	25	25	4.50

73. A schedule of layers and liquors in a tannery using cold, weak liquors is shown in Table VII.

The leather from this tannery is of a very beautiful color, light in weight, and quickly tanned. The sapped liquors are strengthened by returning to the leach house, and no extract is used. The liquors are very pure; in fact, some of them are of such purity that 65 per cent. of the total solids are tannins. With this purity, the spent tan, of course, shows considerable tannin, the amount sometimes running as high as 2.25 per cent. The sides are completely tanned here and are

cropped after finishing. The yard operations are carried on in the usual manner, and the sapped upper layers which return, to do duty as lower layers, are strengthened in the leach house.

74. To show the difference in methods, the schedule of another cold-liquor tannery is given in Table VIII.

This tannery is a typical, modern, union crop tannery, no oak bark, excepting that used for dusting between the leather in the lay-aways, being employed. The union color is made by combining hemlock-, quebracho-, and chestnut-wood liquors, the resulting leather having a good color and all the physical

TABLE VIII

LAYER SCHEDULE FOR UNION TANNING WITH COLD LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Approximate Percentage of Tannin
First	7	16	2.50
Second	11	21	3.25
Third	14	21	3.25
Fourth	22	23	3.75
Fifth	33	25	4.50

characteristics of union leather. The fifth-layer sapped liquor is used for the first-layer new liquor, the fourth-, third-, second-, and first-layer sapped liquors being used as rocker liquors. The new liquors (except first layer) are made by strengthening the leach-house liquor with equal portions of quebracho- and chestnut-wood extract.

75. A warm-liquor tannery using strong liquors and considerable extract had the schedule given in Table IX.

Six layers were in use at the tannery, although ordinarily but five are given. This tannery makes rather heavy leather, of a good color, and the bark used is well leached. Extract

is used for strengthening the liquors, some of which are returned to the leach house for strengthening.

76. The use of weak or strong yard liquors depends on the expected finishing treatment of the leather. In a tannery using wheels for the mechanical addition of tanning material to the leather, the yard liquors are generally weaker in barkometer strength and higher in purity than in yards pursuing the old methods of union-leather tanning. After the yard tanning, the leather is cropped, provided this operation has not been performed previously. It is then finished by rinsing, bleaching, oiling, drying, and rolling, as has been previously

TABLE IX

LAYER SCHEDULE FOR UNION TANNING WITH WARM LIQUOR

Layer	Time in Layer Days	Strength of Liquor Degrees Barkometer	Temperature Degrees Fahrenheit	Approximate Percentage of Tannin
First	7	22	65	3.00
Second	11	24	75	3.50
Third	14	26	80	4.00
Fourth	20	28	90	4.60
Fifth	25	31	100	5.00
Sixth	33	34	105	5.60

described; or, if preferred, it may be wheeled with tanning material, as described under the head of Non-Acid Hemlock Tanning, and then finished in the regular manner. Union crop leather is generally rolled only once, the gloss of hemlock leather not being required on union leather.

77. Quick Sole-Leather Tannage.—To tie up the immense amount of money that is represented by hides in process of tanning by ordinary methods of making sole leather, requires either a large working capital or excellent credit. In either case, the interest on this tied-up money is a considerable item in the cost of tanning. For this reason principally, quick-

tannage methods have been and are being devised with the hope of producing a leather as good as the long-tanned product and without the necessity of employing as much unproductive capital as the manufacture of the latter entails.

Many methods of quick tannage have been devised, some of them of proved merit. Others are useless, some of them being merely schemes of unscrupulous promoters. The most of the methods depend on the constant agitation of the hide in the presence of the tanning agent to produce the quickly tanned leather so much desired. It is in the preliminary treatment of the hides and in the strength and method of applying the tanning material that the methods differ. The claims as to time required vary with each process, some being as low as 48 hours from the time the hide leaves the beam house until it is said to be ready for the dry loft.

In one general class of these quick tannages, rockers similar to those used in the first stages of some kinds of the regular-process sole leather, are employed. In another, revolving wheels, or drums, are used for a part or all of the tanning process.

78. In the process involving rockers, the stock that comes from the beam house is hung on rockers in the tanning vats. The vats are in complete sections and are equipped with the press system. The top of one vat is connected with the bottom of the next, and the liquor supplied to the head, or strongest-liquor, vat gradually works around through all the vats to the weakest-liquor vat, from which it flows to waste, or else to be strengthened. The stock is hung in the vat receiving the weakest liquor, and here it is constantly rocked in contact with liquor coming from the next vat. The liquor gradually becomes stronger until the vat is receiving the strongest liquor. The stock is then removed and may be put into a strong lay-away vat for a few days, or it may be wheeled with strong liquor or extract, according to the particular quick-tannage process that is being used. In some processes, the hides receive a chemical treatment before going into the tan liquors. One method calls for rocking in a liquor composed of salt, alum,

and sodium nitrate; another calls for a light chrome treatment, while others call for other baths of single chemicals or combinations of chemicals. Treatment with weak organic acids is also generally resorted to, in order to bate and plump the stock before going into the tan liquor. All these chemical baths are designed to open the pores of the hide, so as to facilitate the quick combination of the tanning material with the hide, to prevent the *drawing,* or closing up, of the grain when the hide comes in contact with a strong tanning solution, and to taw the hide slightly, so that the absorption of vegetable tannin by the partly mineral-tanned hide is increased and quickened.

79. Another general class of quick-tanning processes requires the use of the revolving drum, or wheel, to effect the tanning. Various styles of wheels have been introduced and patented, and in many cases the style of wheel or drum used is the only protected feature of the process. The wheels are generally about 10 feet in diameter and are revolved at varying speeds. The interior of the wheels used in some processes are fitted with arrangements for fastening the hides by one end or edge, so that as the wheel revolves the hides are submerged in the tan liquor at one point of the revolution and stretched out and drained at another point. Another style of wheel has a removable frame shaped like a skeleton wheel, on which the hides are fastened in a parallel row, the frame being then fastened within the wheel, with which it revolves.

Another patented wheel contains a removable frame to which the hides are attached in a parallel row, but which does not revolve with the wheel. The frame is so constructed that the hides fastened to it are stretched in alternate directions by mechanism actuated by the turning of the wheel. The hide frame remaining stationary, the tan liquor is poured over the hides by means of buckets or carriers attached to the interior of the revolving wheel. The buckets scoop up the liquor at the low point of the revolution and dump it at the high point, thus allowing it to fall over the hides attached to the stationary frame.

All the wheels are fitted so as to allow the admission or removal of the tanning material without interfering with their revolution. One process employs a wheel in which the tanning material in the shape of solid extract is placed in latticed receptacles within the wheel, the weak liquor used in starting being strengthened by the slowly dissolving extract. The wheels used in processes requiring heat, or the admission of air or other gases, are arranged to meet all the requirements of the process.

80. In general, the treatment of the hides in quick-tannage processes using wheels is the same as in the processes using rockers. Some processes call for a preliminary treatment, and others begin with the hide just as received from the beam house. Weak liquors are first supplied to the wheels, the strength being gradually increased as the tanning progresses, until the maximum strength of liquor is being used and the wheel tanning is completed. The wheels are sometimes run in sets, the liquor from a wheel containing hides nearly tanned being run to the next wheel in which the tanning is not so far advanced, and so on to the wheel containing fresh hides. From here, the liquor is run either to waste or to storage to be strengthened. Where the wheel is operated as a unit, each sapped liquor may be run off to give place to a stronger one, or the liquor may be strengthened in the wheel by the addition of strong liquor or extract.

After the wheel treatment, the stock may be bleached and lofted, as in some processes, or it may receive a further treatment by laying away for a few days in a strong liquor, or by being thrown loose into revolving wheels containing strong liquor or extract. When the tanning is completed, the leather is bleached, oiled, dried, and rolled in the same manner as the regular long-tanned leather.

81. Most of the quick-tannage processes are still in the experimental stage, and they find many opponents among the old-style tanners. The principal objection to the processes themselves is found in the accumulation of weak tanning liquor. The hides are treated so that their affinity for

tannin is developed to the highest point, and the strong liquors they receive are sapped quickly; thus, a liquor containing a preponderance of non-tanning matters ultimately results. These sapped liquors may contain considerable tannin, but in the presence of such a large proportion of non-tannins, the tannin itself is not very active and is not available for quick-tanning purposes. The constant strengthening of these liquors serves only to postpone the ultimate end of their usefulness and to increase proportionately the barkometer strength of the waste liquors.

The principal objection to the manufacture of sole leather by quick processes has been its low gain. Unless loaded, or weighted with adulterants, the quick-tanned leather produced at a cost allowing a profit to the tanner, does not show the gain that it is possible to make by the older methods of tanning. In the beginning of the quick process, the first leather produced may show up well as to gain and as to cost of manufacture, but as the process continues it has been the experience of many that gain decreases and costs increase. The waste of unavailable tannin in the sapped liquors and the decreasing purity of the tan liquors are responsible for this condition.

There is also an objection to quick-tanned sole leather simply because it is quick tanned, some persons claiming that it is impossible by shorter processes, to produce a leather with the toughness, mellowness, and fiber of the long-tanned methods. This cannot be proved by the characteristics of quick-tanned leathers taken as a class, as leather produced by quick-tannage methods varies in appearance, texture, and strength just as much as the long-tanned leather.

As previously stated, most of the quick-tanning processes are still in the experimental stage, and the exact status of quick-tanned leather is not yet determined. From present indications, however, it would seem that in the near future the practicability and economy of the quick tanning of sole leather will be demonstrated. Whether experience will show it to be the equal of the old-style leather remains to be seen.

MANUFACTURE OF LEATHER

Serial 416B (PART 2) Edition 3

HEAVY, OR FIRM, LEATHER—(Continued)

SOLE-LEATHER MANUFACTURE—(Continued)

OAK-TANNED BELTING LEATHER

1. Oak-tanned belting leather is really a sole leather, slight changes in the tanning and in the treatment of the leather after tanning being made to produce the tough, mellow leather that is required for belts. The hides should be the best, and the unbranded packer steer hide is used largely for this purpose. The beam-house process is about the same as for other oak leather, except that the hide is not split into sides. The hides are thrown over sticks and hung in the handler liquors, instead of being strung together. After coming out of the handlers, the bellies are trimmed off, and sometimes the heads are taken off at this point. The parts trimmed off are strung together and tanned separately, or they may be thrown in on top of the regular stock.

After trimming out the handlers, the hides, or *butts*, are laid on frames in the lay-away vats and care used to spread out smoothly and remove all creases. The frames are held by ropes attached to the corners and are gradually lowered into the vat as the height of the hides on the frame increases. This stock is generally given five or six layers, the first, and sometimes the second, being sour liquors that have been sapped by higher layers.

COPYRIGHTED BY INTERNATIONAL TEXTBOOK COMPANY. ALL RIGHTS RESERVED

2. The schedule for a typical belting butt yard is given in Table I.

The leather is hoisted twice while in the first lay-away liquor, the hides being removed and carefully piled beside the vat. The creases and folds are removed and the hides flattened out in the piling, and the leather is again laid away in the same liquor. This treatment seems to improve the quality of the butts, and while it is not followed in all tanneries, the appearance of the finished product that has undergone this treatment in the yard would indicate that it is worth while. If the leather out of the first layer is flat and free from creases,

TABLE I

LAYER SCHEDULE FOR OAK-TANNED BELTING LEATHER

Layer	Character	Strength Degrees Barkometer*	Time in Days
First.....	Sour	37	15
Second.....	Sweet	30	10
Third.....	Sweet	33	15
Fourth.....	Sweet	38	30
Fifth.....	Sweet	50	50

there is small probability that the higher layers will cause a permanent crease or wrinkle, as the first layer tends to firm up the soft stock from the handlers.

After being raised from the last layer, the stock is put into cold water overnight, and then into water ranging from 90° to 100° F. for the same length of time. It is then taken out of the warm water, carefully piled, and allowed to drain. When drained, it receives a hand oiling with cod oil on the flesh side and it is again piled to allow the oil to work into the leather. The leather is then lightly oiled on the grain side, taken to the dry loft, and, when dry, is ready for shipment.

*See Art. **23.**

3. Harness Leather.—Green, salted, heavy cow and steer hides that go through the regular liming process in the beam house are used for harness leather. The hides are bated with oropon, or with an organic-acid solution. Rockers are used to rock the sides in the first weak tanning liquors. After the rocker treatment they receive three or four lay-away liquors, oak bark being used between the layers of leather in the vats. The best harness leather is pure oak-bark tanned, but much of the present product is tanned with liquors made up of chestnut-wood and quebracho extract in combination with oak- and hemlock-bark liquors. The flesh is given a smooth surface by *skiving*, or shaving, when the leather is pretty well struck through.

4. After tanning the leather is scoured. It then receives a light coat of cod oil on the grain side and is hung up to sammie, or season. When properly seasoned, the sides are thrown on the setting table, the flesh smeared with tallow and oil, and the grain side thoroughly worked with a stone. It is then given another coat of cod oil. The flesh side is then worked, additional oil and tallow are put on, and the side suspended to dry slowly. When nearly dry, the grain side is again worked, or set, and oiled, and the side is again hung up to dry. From the loft the leather is piled and remains in the piles for 10 days or more, when it is buffed and blacked. The buffing is generally done by hand, a light shaving of the grain being removed to obtain a uniformly smooth surface. After buffing a hot solution of sal soda and logwood is applied with a stiff-bristled brush, and thoroughly rubbed in. This saponifies the surface grease and oil, so that it will not interfere with the coloring. It also mellows the grain of the leather. The blacking is then applied with a soft brush, or swab, and then allowed to dry partly. After this another application of a thin mixture of oil and tallow or stearin is given the leather, which is rehung on sticks. After a hand setting-out on the following day, a final coating of oil and tallow is applied and the leather is again hung up to dry. After drying the sides are removed from the racks and arranged in piles where they remain from 1 to 2

weeks. The leather from the piles is finished by slicking off the grease from the flesh side and smoothing it. The grain side is then slicked and brushed and finally rubbed with a woolen cloth. The leather is then trimmed and graded for market.

VEGETABLE TANNING MATERIALS

5. As a result of the diligent research that has been going on for many years the number of available vegetable tannins has been greatly increased and as a result the cost of tanning materials has been lessened.

Of late years the economical leaching of the bark has served to lengthen the time during which the native barks will be available. The use of wood extracts has also served to protect and increase the life of bark tanning, and as the supply of wood from which these extracts are made is practically unlimited, this generation at least has nothing to fear from a shortage of tannins.

6. In tanning hides for sole leather, the following vegetable tanning materials are most frequently used:

Hemlock bark is the most important vegetable tanning material used in America, about 60 per cent. of all leather being tanned by it. It is the bark of *Abies Canadensis*, and in the East it contains about 11 per cent. of tannin. The tannin content of Western hemlock runs as high as 18 per cent. Hides tanned with it make tougher leather than those tanned with oak bark, but the leather is not as pliable. Both solid and liquid extracts of hemlock bark are also on the market.

Oak bark is also one of the important tanning materials. It is the inner bark of several varieties of the oak tree, as the English oak (*Quercus robur*), the rock-chestnut oak (*Quercus monticola*), and the yellow oak (*Quercus tinctoria*). White oak (*Quercus alba*) and the red oak (*Quercus rubra*) are not so valuable because of their lower tannin content and undesirable color. The tannin of the several varieties of oak is known as quercitannic acid, $C_{17}H_6O_9$. There are four anhydrides of this acid, the first, phlobaphene, $C_{34}H_{30}O_{17}$; the second, $C_{34}H_{28}O_{16}$;

the third, Oser's oak red, $C_{34}H_{26}O_{15}$; and the fourth, Löwe's oak red, $C_{34}H_{24}O_{14}$. Quercitannic acid and phlobaphene only are of importance in tanning.

Canaigre (*Rumex hymenosepalus*) is a native of the dry Southwest. Some recent attempts have been made to cultivate it and introduce it as a tanning material, but with little success. The coloring matters and starch extracted from it affect the quality of the leather.

Quebracho is the name of several hardwood trees growing in South America. The wood and bark of *Quebracho colorado* contain from 15 to 20 per cent. of a bright-red tannin, but do not contain enough non-tannins to aid the formation of fermentative acids necessary to plumping, nor will it yield a full, well-nourished leather unless combined with other forms of tanning agents that are richer in non-tannins.

Palmetto root is obtained from the palmetto tree found abundantly in the Southern lowlands. This root has been attracting considerable attention for the past few years among Southern tanneries. The root is cut up and treated like bark. Its action is quick, and the leather tanned by it is tough.

Gambier (*pale catechu*) is an important tanning agent. It is the dried extract from the leaves of *Uncaria gambier* and *Uncaria acida*. The extract is readily soluble in warm water. It contains from 36 to 40 per cent. of a brown tannin that penetrates hides rapidly and tends to swell them; taken alone, it produces a soft, porous tannage. It is largely used with other tanning materials for both light and heavy leathers. It is exported from Singapore in pressed blocks and cubes.

Catechu, or *cutch*, is the dried extract of an East Indian tree, *Acacia catechu*. It contains from 45 to 55 per cent. of a special variety of tannic acid. The extract is evaporated until a thick, dark-brown product is obtained, which solidifies on cooling, and is exported in this form.

Gallnuts, or *nutgalls*, are excrescences on certain plants, caused by gall flies, which puncture the bark in order to deposit their eggs. Oak gall, or Aleppo galls, and Chinese galls are the most important. The oak gall is formed by the insect on *Quercus infectoria*. The eggs hatch and the larva develops

within the gall. The best galls are gathered before the fly becomes fully developed, and contain from 60 to 70 per cent. of gallotannic acid. The Aleppo galls are the most valuable.

Mangrove bark has of late years become popular as a cheap tanning agent. The mangrove tree grows in swamps in tropical and semitropical countries, and the bark contains a quantity of tannic acid, varying with the locality of growth. The African bark is the strongest in tannin, running as high as 45 per cent.; South- and Central-American bark contains as much as 28 per cent., while the Florida bark rarely has more than 22 per cent. of tannin. When used alone, the African bark gives a rather harsh leather of a bright-red color, but it makes an admirable combination with native American barks.

Sumac in all its varieties is a common and valuable tanning agent. It consists of the powdered leaves of the so-called tanners' sumac (*Rhus coriana*, *R. typhina*, etc.). The best sumac comes from Sicily, but Italian, Spanish, French, and American sumac is also found on the market. Sumac contains from 15 to 30 per cent. of a light-colored tannin, which is in great demand in the manufacture of some classes of leather.

Chestnut wood is largely used for extract manufacture in the United States, but, mixed with bark, its use in the tannery leach house is becoming quite common. The wood found in the Northern states contains from 5 to 8 per cent. of tannin, while Southern chestnut wood often contains as high as 11 per cent. of tannin. The chestnut tree, being of quick growth, offers a solution to the problem of offsetting the decrease in vegetable tanning agents. The chestnut blight, however, which has devastated the Atlantic Coast, places this industry in a very serious position, and every effort is being made to check the disease.

Valonia is the commercial name for the acorn cups of several species of oak (*Quercus ægilops* and *Quercus macrolepis*) coming from Asia Minor and Greece. They contain from 25 to 35 per cent. of tannin, somewhat resembling that of oak bark, but giving a browner color and heavier *bloom*. It makes a hard, water-resisting leather and is sometimes mixed with oak bark for use in sole-leather tanning.

Divi divi is the dried seed pods of a South American bush. The pods are about 3 inches long, of a brownish color, and in drying bend in the form of the letter S. These pods contain from 30 to 50 per cent. of a peculiar tannin somewhat similar to that of valonia.

Myrobalans are the dried fruit of several species of *Terminalia* from Hindustan, Ceylon, and other countries. They contain from 28 to 35 per cent. of tannin, and are generally used in combination with other tanning agents. Some varieties cause a bloom similar to that of oak bark, and all varieties are great acid formers in the tan yard.

Mallet bark is an Australian product containing as high as 50 per cent. of tannin similar in color to oak bark.

7. Classification of Tannins.—The tannins in tanning materials are different members of a large group of organic bodies known chemically as *tannic acids*, or *tannins*. They differ widely in chemical constitution and reaction, but all have the common property of precipitating gelatine and forming soluble compounds with animal tissue. They are all compounds of carbon, hydrogen, and oxygen, but their ultimate structure is little understood.

When heated, the natural tannins yield catechol, $C_6H_4(OH)_2$, or pyrogallol, $C_6H_3(OH)_3$, and sometimes both. The classification of tannins on these chemical lines bears out an old classification made on the appearance of the tannage.

8. Tannins were formerly divided into those which yield the whitish deposit on the surface of the leather, called *bloom*, and those which do not. Most tannins that give a bloom to the leather are *pyrogallol tannins;* a solution of their non-tannins when separated has an opalescent appearance. The tannins that give no bloom to leather are classed as *catechol tannins.*

When treated with sulphuric acid, the pyrogallol tannins yield gallic acid or ellagic acid, the latter combining with tannic acid to form the bloom. Under this treatment, the catechol tannins yield the reddish-brown insoluble bodies known to all tanners as *reds*. These reddish-brown insoluble bodies differ from the original tannins in containing fewer molecules of

water, and are, therefore, anhydrides of their especial tannic acids.

Hemlock bark yields a series of these reds; the higher members are soluble, precipitate gelatine, and are the principal coloring materials of the bark. The lower members are insoluble at ordinary temperatures and form the sediments found in the tannery vats.

9. Wood and Bark Extracts.—The use of wood and bark extracts in the process of tanning is becoming more general every year. There are few tanneries where extract is the exclusive tanning agent, and but few tanneries where it is not used to some extent. Primarily, an extract is valuable because of the annual decrease of tan bark that its use has brought about. It brings the strength of distant virgin forests to the aid of our own failing supply of bark. It is decidedly useful as a convenient means of strengthening a weak liquor quickly, without the addition of the same amount of insolubles that would be added were the ordinary bark liquor used. The extracts made from some barks and woods are valuable for the color that they impart to inferior tannages on which they may be used.

In sole-leather manufacture, extracts are generally used for strengthening the liquors and occasionally for improving the color of the stock. In some branches of the upper-leather industry, the pelts are partly tanned in bark liquors and then finished in liquors made up entirely of extracts. In this way the distinctive characteristics of the tannin of the bark or wood from which the extract was made, are imparted to the skins.

In the shortened method of modern sole-leather tanning, the undiluted liquid extract is *drummed* into the tanned hides, thereby saving time and increasing the weight of the leather.

10. Manufacture of Extracts.—The manufacture of extracts is carried on to a large extent in the United States, South America, Europe, and Asia. Wherever there is a sufficient supply of tanning material, handicapped by prohibitive freight rates, the extract works solve the commercial problem of economical distribution.

The material to be extracted is ground fine and the leaching takes place in the same manner as at the tannery; details as to the duration of the leaching, temperatures, etc., are determined by the particular substance undergoing extraction. To remove fine, insoluble materials, the liquor is then treated by some sort of clarification process, either mechanical or chemical, or both.

Numerous methods of clarification are in use among extract manufacturers. Dried blood and other albuminous products are used and in coagulating, envelop the solid particles and settle out. Inorganic processes, such as the use of acetate of lead, or the direct precipitation of barium sulphate in the tank, have been devised, but these processes remove more or less tannin, in addition to the insolubles taken out. Purely mechanical processes of clarification consist in the settling of the liquor in vast settling tanks or by slow filtration through some coarse fabric.

The older methods of clarification depended on the removal of the insoluble particles, or reds, to accomplish the clearing of the liquors. The later clarifying processes aim to make these reds soluble, thus making a clear extract, and at the same time rendering the reds available as tannins. For this purpose, sulphurous acid, alkalies, or bisulphite of soda are used. When these chemicals are used, the clarification of the extract should not take place until the concentration of the liquor has been nearly accomplished. The use of alum or salts of aluminum and chromium, is also frequently resorted to, in order to remove from some extracts the objectionable red color like that made from hemlock bark, and also from some varieties of quebracho wood.

11. The liquors from the leach house are concentrated in vacuum apparatus, multiple-effect vacuum pans generally being used because of the resulting economy in the cost of operation. A standard quadruple-effect pan is shown in Fig. 1. Each *effect* is exactly like the others and consists of a cylindrical copper body *a* bolted to a steam drum *b*. The steam drum in a standard vacuum pan consists of a circular drum of copper having a great number of vertical copper tubes, the upper and

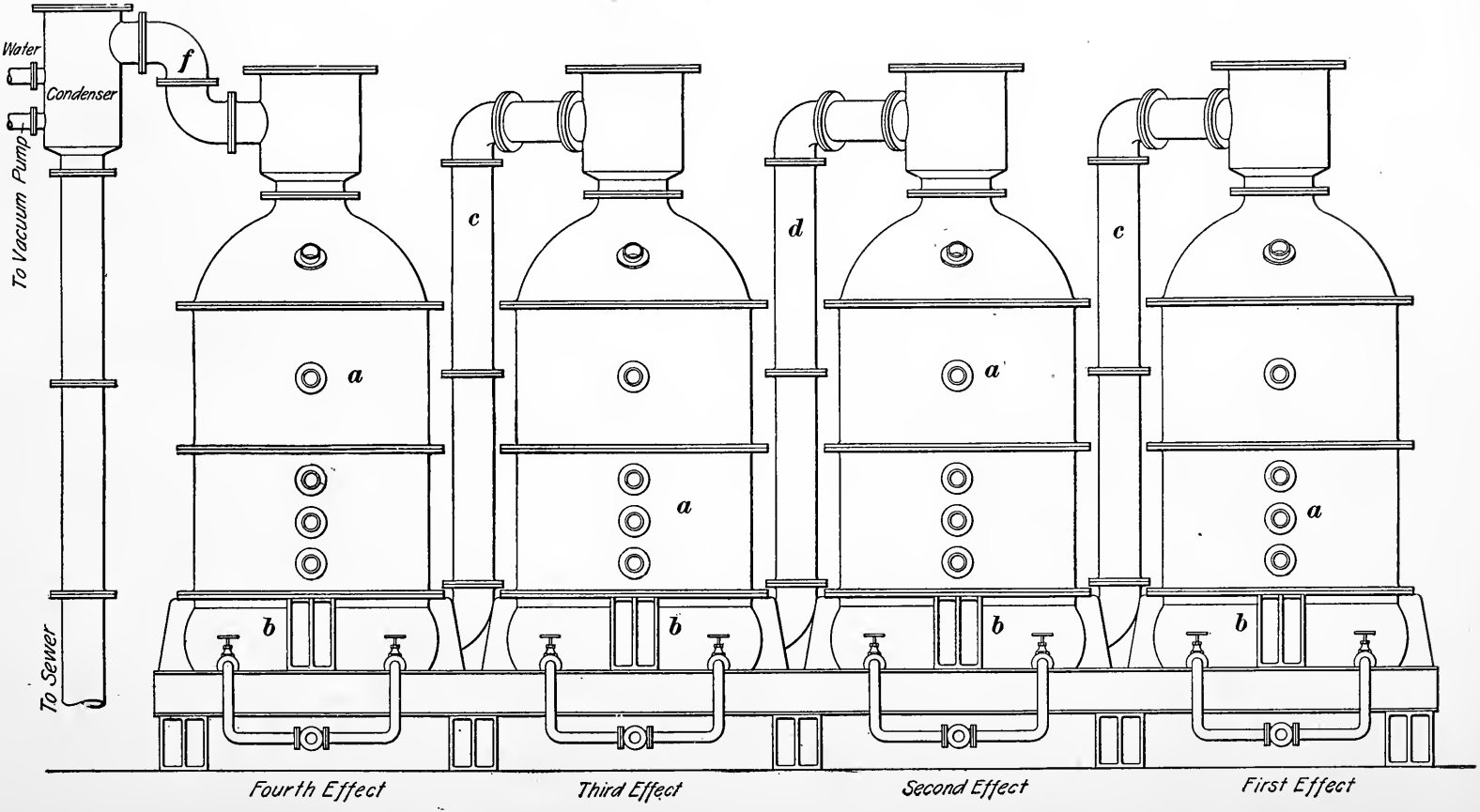

Water
Condenser
To Vacuum Pump
To Sewer
f
c
d
c
a
a
a
a
b
b
b
b
Fourth Effect
Third Effect
Second Effect
First Effect

FIG. 1

lower ends of which are expanded into openings in the upper and lower heads of the drum. The steam drum has a circular well in the center, generally of a diameter equal to one-third the diameter of the drum. The purpose of the well is to help the circulation of the liquors while they are boiling. Vapor pipes lead from the top of the body of one effect to the steam drum of the next, the vapor pipe from the last effect being connected with the condenser. Pipes for conveying the thin liquor to each pan, and for conveying the liquor from one pan to the other, are provided. Pipes for conducting the condensed steam and vapors from the steam drums and for removing the finished extract from the last effect are also provided.

Liquor is put in the pan, condensation water removed from the steam drums, the finished extract removed from the last effect, and the vacuum maintained by different pumps adapted to the work.

12. In operation, the pans are charged with liquor, pumps are started, and steam turned into the steam drum *b* of the first effect; the steam surrounding the multitude of tubes in the steam drum is rapidly condensed, and the liquor in the pan soon begins to boil. The vapor from the boiling liquor passes through the vapor pipe *c* into the steam drum *b* of the second effect, gives up its heat to the liquor in this effect, and is condensed. The vapor from the liquor in the second effect goes through the vapor pipe *d* to the steam drum *b* of the third effect, and the vapor from this effect goes through the vapor pipe *e* to the steam drum *b* of the fourth effect. The vapor from the fourth effect goes through the pipe *f* to the condenser, where it is condensed by a spray of cold water. The condenser is attached to a leg pipe about 35 feet long, having its lower end sealed in a water well overflowing to the sewer; the suction pipe of a vacuum pump is attached to the lower part of the condenser and maintains a vacuum of from 24 to 27 inches of mercury in the condenser and last effect. This lowers the boiling point to such an extent that liquor boils in the last effect at a temperature close to 150° F. Vapor coming from the third effect is quickly condensed in the drum of the fourth effect

and causes a decrease in pressure in the body of the third effect. The boiling point in the third effect is thus lowered, causing a slight vacuum that influences the pressure and boiling point in the second effect, and in turn the condensation of vapors coming into its steam drum is thereby quickened.

The vacuum on the first, second, and third effects is materially increased by the suction of the pump used to remove the condensation from the drums. In practice, it is customary to maintain a steam pressure of 5 pounds on the drum of the first effect, a very slight vacuum in the first effect, and a regular increase in vacuum thereafter, until the maximum is reached in the last effect. The liquor is pumped into the first effect, from which it is sucked to the second, and from the second to the third, and from the third to the fourth, the liquor in all effects being maintained at the desired level by regulating the valves on the pipes connecting the pans, so that enough is admitted to replace the amount evaporated. When the desired concentration is reached, the extract is slowly pumped from the last effect to the clarifying tank, or to the storage tank in case the liquor is not to be clarified.

13. Some extracts are marketed with a specific gravity of 1.22, or 44° Twaddell, others are still further reduced to a specific gravity of 1.26, or 52° Twaddell, while practically all the foreign extracts come to the United States in the solid form, containing from 20 to 25 per cent. water. For evaporating to dryness the strike pan or drum dryer is used.

Hemlock-bark extract has been longest on the market. It is made from the common hemlock bark in localities where hemlock grows plentifully and is shipped to other less-favored points.

Rock-oak bark, chestnut-oak bark and wood, mangrove, sumac, quercitron, mimosa, quebracho, gambier, acacia, and other woods and barks are extracted, and their extracts form valuable adjuncts to the ordinary tan liquor.

Among American tanners, the standard extracts are quebracho and chestnut wood.

Quebracho extract is made from the wood of the quebracho tree, a close-fibered South American wood. It produces a

fine-colored tannage, but is better adapted to the tanning of upper leather than for sole leather, as its low non-tannin content tends to keep it *sweet;* that is, it does not foster the growth of organic acids necessary to plumping.

Chestnut-wood extract is made from the wood and bark of the chestnut tree, found in nearly all parts of the United States. Used in connection with other tanning materials, it is perhaps the most valuable of extracts. The tree grows quickly, and if the young trees on a stripped tract are forested, the original growth will be duplicated and large enough to cut in 15 or 20 years.

14. Preparation and Leaching of Bark.—The leaching of bark is an operation in tanning which has caused the loss of thousands of dollars through improper manipulation. Even at this late day, tanners are leaving in the cast-off bark as high as 25 per cent. of its original tannin content. When the theory of leaching is thoroughly understood, there will be no such wanton waste.

The principles of saturation and equalization underlie the theory of leaching. A piece of hot iron placed in water loses its heat to the water and becomes colder, while the water is warmed by the iron and finally both iron and water are of the same temperature. The same principle is involved in the process of leaching; both the leach and liquor ultimately become of equal strength. A strong liquor run on a spent leach will come off the leach weaker than when it ran on. In a perfect leaching system, the object is always to run a liquor on a leach that can add tannin to the liquor.

15. Preparation of Bark for Leaching.—Various methods of preparing the bark for leaching are in use. They all consist of some kind of grinding and shredding. Proper preparation of the bark is important and quite essential to close leaching; the best leaching system will not produce good results unless the bark is reduced to such a state that the water or liquor can readily penetrate to every fiber.

Mills for grinding bark have the common feature of a revolving disk into which cutting knives are set radially. Most of

them have a secondary disk that completes the work which the first disk started; the bark then passes through small apertures to a conveyer.

16. Ott Bark Mill.—The Ott mill, shown in Fig. 2, is the most popular of the grinders. It consists of a hopper *a*,

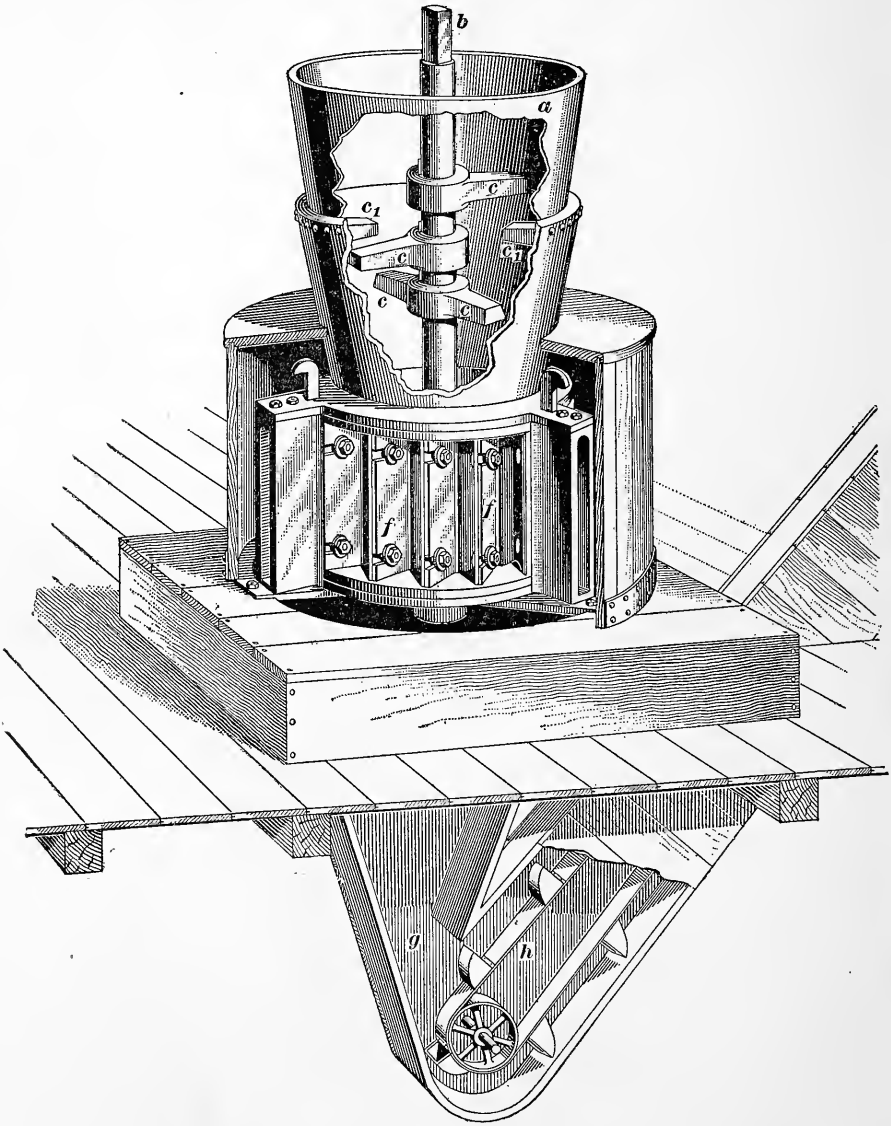


FIG. 2

leading to the lower part of the mill, where the grinding is done. A shaft *b*, by means of which the mill is driven, runs

through the center of the entire mill, which may be driven by it from either the top or the bottom. The portion of the shaft running through the hopper has keyed to it four projecting iron arms c, which, with the aid of similar projections c_1 from the inner sides of the hopper, break the bark into small pieces that fall into the runner, or carrier, shown in Fig. 3 (a). The runner, or carrier, consists of a circular piece of steel d fitting the lower part of the mill; it is attached to and revolves with the shaft that passes through its center. Attached to the shaft above this disk are four angular iron wings e that

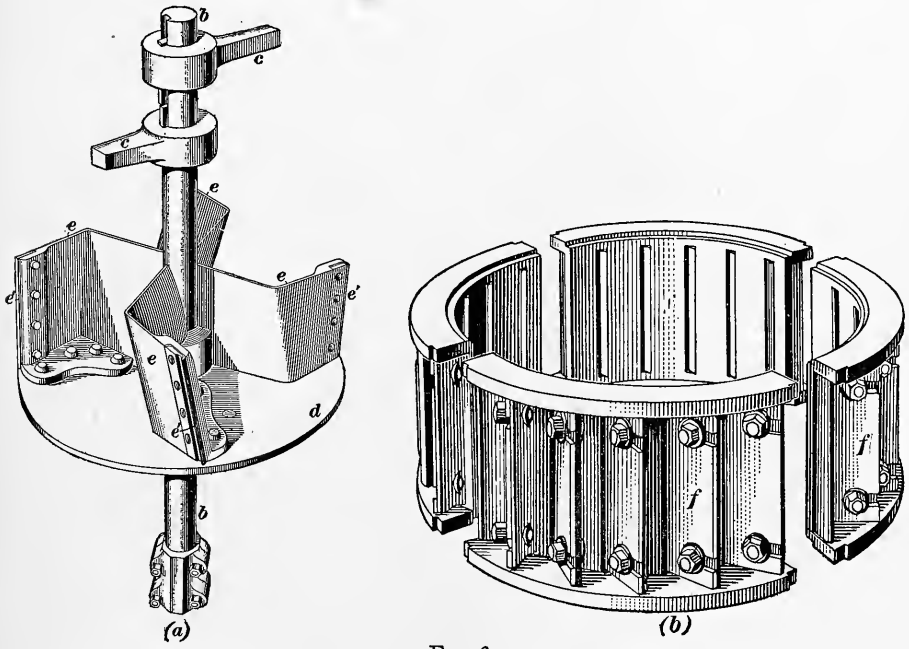


FIG. 3

extend to the edges of the disk and are attached to it by bolts engaging the flanges of the wings. The ends of the wings are supplied with steel tips e' that form a cutting surface. The knives f, Fig. 2, are set vertically and bolted to a slotted cylinder of the same height as the runner, and surrounding it. The bark, having been broken by the upper arms, falls into the runner and is ground by being carried against the knives by the steel-tipped wings. Passing through the knife slots, the bark falls into the bottom of the grinder and is delivered by means of a spout g to the carrier h, which takes it to the leach house.

The cylinder, shown in Fig. 3 (*b*), containing the knives *f*, is made in segments that can be removed for the grinding and setting of the knives, five of which are held in each segment. The mill is run at a speed of 100 to 150 revolutions per minute; the knives require grinding and setting at intervals which depend on the character of the material that is ground.

Many tanners prefer a shaving machine that reduces the bark to shreds instead of grinding it. With oak bark it gives better results than the ordinary grinder.

17. Williams Patent Bark Shredder.—The machine shown in Fig. 4 is the best known form of the shaving, or

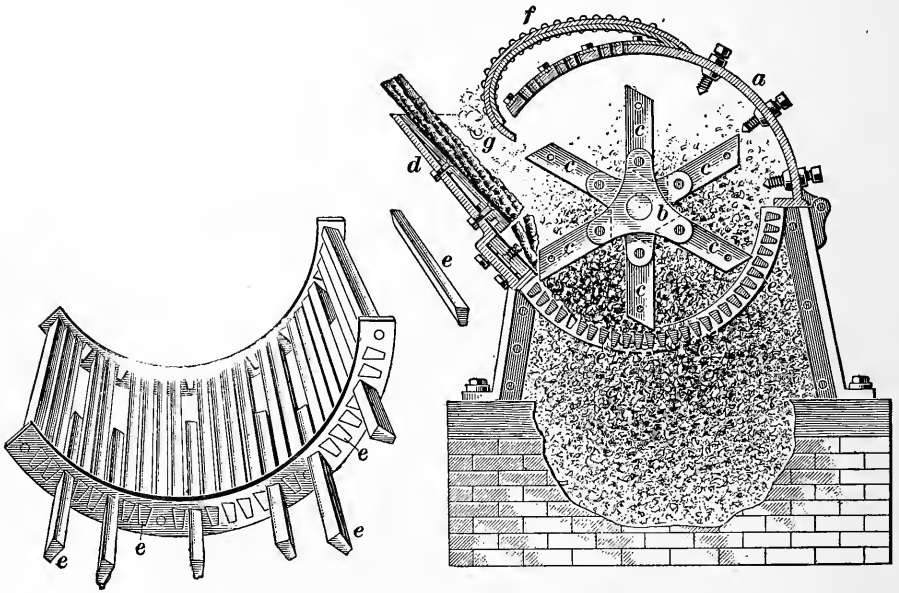


FIG. 4

shredding, type of machine. It is cylindrical in shape, the casing *a* surrounding a horizontal shaft to which a hub *b* is keyed. Heavy, sharp-pointed arms, or hammers, *c* that present a cutting edge, are hinged to the hub by pinions, and when the shaft is in motion the centrifugal force causes them to radiate from the hub. The hopper *d* is at the side, the floor of the hopper being inclined by a raised plate, the end of which forms a sharp breaking corner so that the bark is cut in small pieces before the final shredding takes place. A segment of a cylinder, shown at the left in Fig. 4, contains the knives *e*

and is so placed beneath the revolving arms that the edges of the knives and the sharp ends of the revolving arms form shears and cut or shred the bark forced between them. The shredded bark then falls between the knives into the conveyers. The segment, or *cage*, containing the knives is in the form of a semicircle, and the knives are so arranged that the lip, or projecting edge, presents a shaving, or shredding, surface rather than a pulverizing surface. The knives can be taken from the cage, resharpened, and replaced. A bowed steel shell *f*, with one edge riveted to the top of the casing and the other edge projecting through the hopper opening into the cylinder, forms a chamber for the settling of the dust after it has been moistened by a spray of steam introduced at the side of the hopper at *g*. Economy of power with greater grinding capacity is claimed for this type of machine; it is especially valuable for wood and barks of a fibrous nature.

When ground, the bark is conveyed to the leach house by a mechanical conveyer or blower, the former being the cheaper method of conveyance.

18. Vat Leaching.—Most of the older leach houses were constructed by sinking the vats in the ground. While this method seems to economize the heat used in latter-day leaching, inability to repair leaks is a serious objection to this form of construction, and all the newer types of leach houses are constructed with the bottoms of the vats above ground. In this way, leakage is detected and stopped, and the spent, or exhausted, tan is much more easily removed from the leaching vats. Mechanical contrivances for handling the bark before and after leaching are in general use. The vats, or *leaches*, are filled from an overhead conveyer leading from the bark storehouse; and when the bark has been leached, the spent tan falls through an opening in the bottom of the vat into a conveyer that takes it to the furnace, where it is used as fuel.

The vats used for leaching are usually arranged and worked in sets; the vat containing the freshest bark is known as the head-leach and that containing the nearly spent bark is called the tail-leach.

The vats, or leaches, arranged in sets or sections are provided with perforated false bottoms, and they are so piped that the liquor from the bottom of one leach is delivered to a box on the top of the next leach in the section and falls either directly on the bark or is distributed over its surface by means of an arrangement known as the *sprinkler*. The sprinkler is made of two pieces of brass pipe screwed into a tee, which, by means of a swivel joint, is connected with the pipe leading down from the box on top of the leach. Each arm of the sprinkler has a row of perforations, and the ends of the arms are closed by removable caps to allow cleaning. The perforations on one arm are opposite those on the other, so that when liquor flows through the box into the sprinkler one arm delivers liquor in one direction, and the other arm delivers it in the opposite direction. This causes the sprinkler to revolve and spread the liquor over all parts of the bark.

19. The general scheme for leaching with vats is to run water on the tail-leach, and after the liquor comes off it is put on the next, and so on throughout the set until the liquor comes off the head-leach, when it is sent to the settling tanks or storehouse. The tail-leach, after receiving all the water intended for it, is emptied or *pitched*, filled with fresh bark, and becomes the head-leach, the leach next above it becoming in turn the tail-leach.

This method of handling the liquors is common to all systems of vat leaching. It is in the method of applying the water, of removing the liquor from leach to leach, the temperature of the liquors, the depth of the vats, and in many other minor details that the various systems differ.

With some systems, the use of warm liquors on every leach is advocated, the water going on the tail-leach being as near the boiling point as possible; the water becomes cooler as it goes to the next leach and finally becomes too cool, in the judgment of the advocates of this system, and is reheated.

Some leaches have steam coils, protected from the bark by a false bottom, in order to maintain the temperature deemed necessary for proper leaching. Other leaches have in the box

on the top of the leach a coil of steam pipe for heating the liquor from the preceding leach. Hot leaching, if not carried to extremes, is the most economical method. When the continued use of very hot waters is resorted to, the reds and the resinous matters of the bark are dissolved in the liquor. These reds are of no use in tanning operations, and serve to make an impure liquor, because their proportion to the amount of tannin that is removed by the extra heat is altogether too large to be economical.

Within certain limits, the higher a column of bark through which a liquor passes, the stronger is the liquor and the more perfect the leaching; the weight of the column is limited by its interference with the circulation of the liquor. When the leach is too deep, the bark packs down tightly and stops the even percolation of the liquor.

20. In some systems of leaching, the liquors are moved from leach to leach by pumps worked by a common rod. The conditions, however, are not the same in each leach, and hence pumping devices should be fitted to each leach separately, so that the regulation of their speed may be under control.

The *air* system of handling leach-house liquors is now quite common, and it is probably the best method of moving these liquors. Compressed air is admitted to the bottom of the upright pipe that conveys the liquor from the bottom of one leach to the top of the next, and raises the column of liquor in the pipe until it flows into the liquor box on the top of the next leach.

The practice in some tanneries is to empty a leach of liquor entirely and then run on more liquor. The leaches should be kept covered with liquor at all times. If one is drained free from liquor, the bark settles down and packs tightly; the liquor running on the bark in this state channels its way to the bottom and uniform percolation is not secured.

A constant and slow influx of liquor on the leach is preferable to a large stream. The liquor should be given a long contact with the bark. It should be delivered on the top of the leach in a divided stream and not in a single strong jet. Liquors that are partly spent are frequently returned to the leach

house in order to be strengthened and to keep up the general strength of the leach-house liquors. The returned liquors are generally run on the upper leaches of the section, as the lower leaches, being nearly spent, would take strength from, instead of adding strength to, the liquor. While the partly spent liquors have lost a considerable share of their tannin during the tanning operations, they still retain a large proportion of their original non-tannin content; when strengthened, therefore, they do not represent the tannin strength that is possessed by a new liquor of the same specific gravity.

21. A complete description of a leaching system will give a general idea of the mode of operating. The leaches are circular in form, 12 feet in diameter, and 15 feet deep, with plank covers, and with heater boxes on top of them. The liquors are moved by means of the air system. Water as near a temperature of 212° F. as possible is run on the tail-leach, from the bottom of which it is pumped to the heater box of the next leach. Here it is reheated while passing over the steam coils and falls through a pipe into the leach. The liquor passes through each leach successively and is reheated until it reaches the leach next to the head-leach. Here, it is not reheated, but passes through the bark and comes into the box on the head-leach at about 150° F. The sprinkler used on the head-leach distributes the liquor over the surface of the bark. When the head-leach is *wet down* or filled with liquor, the liquor is run off to the *cooler* or storage vats. The pumping from this head-leach is continued until the liquor becomes too weak for use in the tannery. When used yard liquors are returned to the leach house, they are pumped into the heater box on the top of the head-leach, heated, and distributed over the bark by the sprinkler. After all the returned liquor has gone into the heater box, the liquor from the leach next to the head is pumped into the head-leach and the regular leach-house process continues.

The bark in the leaches is kept covered with water or liquor at all times, and the pumping from one leach to the next is regulated with this end in view.

The preceding remarks on leaching apply particularly to the leaching of such common barks as hemlock and oak, but with other materials the general principles are the same, and, except for variations in the size of leaches and in the temperature of operation, the method of procedure is similar.

22. For some materials rich in tannin, *autoclaves*, or metallic cylinders, in which the leaching is carried on at different pressures, are used. Drum-leaching systems have been used on oak and hemlock barks, but for these materials they are not necessary; drum systems have been very successfuly used in the leaching of some high-priced imported barks and woods containing high percentages of tannin.

23. Density, or Specific Gravity, of Tan Liquors. The density of tan liquors is determined by means of a form of hydrometer called a *barkometer* and having a graduated scale showing *degrees barkometer*, or, as it is generally written, degrees "Bk." One degree Bk. represents the density of a liquor having a specific gravity of 1.001, barkometer degrees being the decimal portion of the specific gravity figure read in thousandths; thus, 10° Bk. is specific gravity 1.010, 45° Bk. is specific gravity 1.045, etc.

A barkometer merely shows the density of a liquor, or its weight compared to that of water; it cannot determine the tannin strength of a liquor, as one 20° Bk. tan liquor might contain 3 per cent. of tannin and another liquor of the same density might contain only 1.5 per cent. of tannin. Non-tannins and other soluble constituents of tan liquors influence the density, and hence the mistake should not be made of considering a 25° Bk. liquor necessarily stronger in tannin than a 20° Bk. liquor. The barkometer readings should be made with the liquor at a temperature of 60° F., or else a correction should be made to compensate for the expansion or contraction of the liquor. If warmer than 60°, the liquor will show less barkometer strength; if colder, it will show more, so that all readings should be made at, or corrected to, 60° F.

The specific gravity of an extract is generally denoted in degrees Twaddell. One degree Twaddell is equivalent to a

specific gravity of 1.005, being one-fifth of the decimal portion of the specific-gravity figure when the latter is represented in thousandths. Thus, specific gravity 1.225 is 45° Twaddell, specific gravity 1.400 is 80° Twaddell, etc. From this relation, it is evident that 5° Bk. is equal to 1° Twaddell, or 45° Twaddell is 225° Bk.

ANALYSIS OF TANNING MATERIALS

24. The methods of analysis for tanning materials have been gradually developed and are peculiar to this class of work. In addition to the general laboratory equipment of apparatus and chemicals, there are needed special contrivances and preparations, such as extraction apparatus, devices for shaking, animal charcoal, and a supply of hide powder.

ANALYSIS OF BARK, WOOD, ETC.

25. Preparation and Extraction of Sample.—The sample is ground so that it will pass through a sieve having 20 meshes to the linear inch. It is well mixed, and a 10-gram sample is dried overnight in a steam oven for moisture determination. A weighed portion of the bark is then extracted in some form of extractor suited to the nature of the material under examination. In all cases, the extractor should be of such form as to permit the removal of the first, or strong, portions of the extractives, so that these will not be subjected to the influence of sustained high temperatures. For materials like oak and hemlock bark or chestnut wood, a different method of extraction from that required for sumac, algorahilla, etc., may be used.

26. The Reed Extractor.—An extracting apparatus suited for use on all materials is that known as the *Reed extractor*, which is shown in Fig. 5. By varying the method of operation, practically all tanning materials may be extracted by it. For use on sumac or like materials, which do not allow of an initial extracting temperature of boiling water, the material is weighed into a cup *b* that has a perforated brass

bottom and rests on a perforated plate *d* of the outer vessel *a*. Water is placed in the vessel *a* surrounding the cup *b* and is kept at the desired temperature by heat applied to the bottom of *a*. Suspended over cup *b* is an inverted vessel *c* filled with water and having an outlet *e* at a higher level than that of tube *f*.

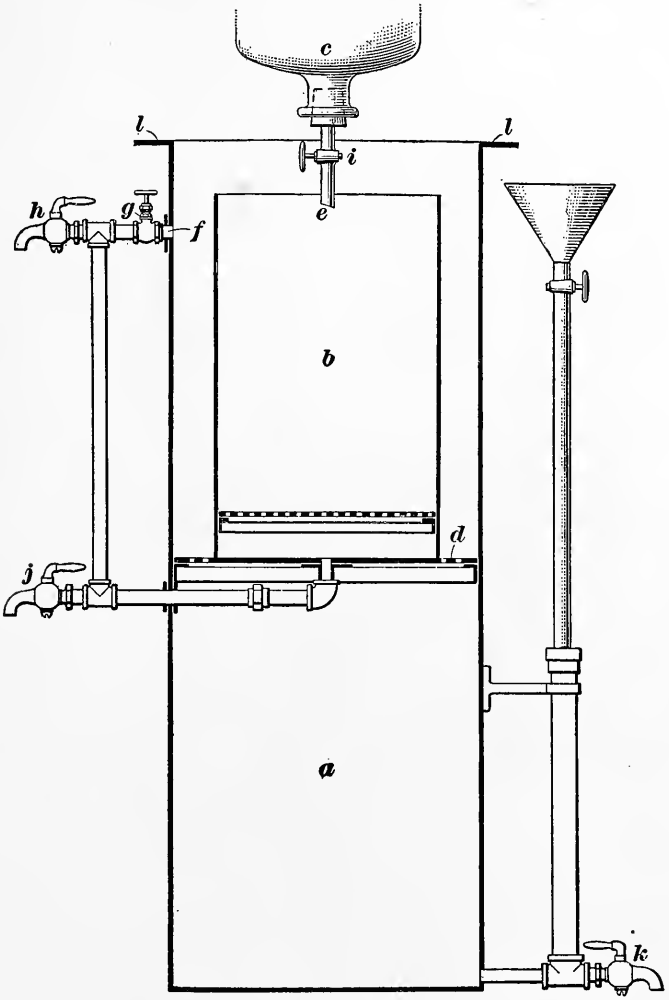


Fig. 5

Cocks *g* and *h* are closed and cock *i* is opened, and water is allowed to flow into the cup. When the desired temperature is attained, cock *j* is partly opened and percolation begins, the extractives being delivered through cock *j* at any desired speed, additional water flowing from *c* as the level falls below the opening *e*. When the strong extractives have been removed,

cock *j* is closed and some of the water surrounding *b* is drawn off through cock *k* until about 600 cubic centimeters of water remains in the bottom of *a*. The inverted vessel *c* is removed and to the flanges at *l* is attached a conical cap to the apex of which a condenser tube is brazed. An annular ring fitted to the interior surface of the cap serves to guide the water of condensation, so that it falls into the cup *b*.

The water in *a* is then boiled and the condensed steam falling into the cup *b* completes the extraction. The extractives may be delivered directly by closing cock *g* and opening either *h* or *j*. If continuous operation is desired, cocks *h* and *j* are closed and cock *g* is opened, and the extractive is returned to the lower part of *a*.

27. The Teas Percolator Extractor.—The Teas percolator extractor, shown in Fig. 6, may be used on all new materials, but a large volume of weak extractive solution results if used on spent or leached materials. It consists of small cylinders surrounded by a heating jacket *a*, the latter being supplied with water from a reservoir through *b*. The reservoir is located above the apparatus so that, when desired, the boiling point of the water may be raised above the normal boiling point. In operation, the perforated disks on the ends of brass rods *e* are covered with a thin layer of cotton or filter paper and the weighed material is brushed or washed into the cylinder and covered with water. Heat is applied to the bottom of the jacket, and when the desired temperature is attained, the cocks *c* are opened and hot water allowed to drip on the material. The extracted material is delivered through any of the cocks *d*, depending on whether a flooding or a time percolation is desired. After the first portions of the extractives are removed, the heat is raised to the boiling point and the extraction completed.

28. The Teas Cumulative Extractor.—For all spent materials, as well as new materials, like oak and hemlock bark, etc., the Teas cumulative extractor, shown in Fig. 7, is more convenient than the percolative extractor described in the preceding article. The cumulative extractor may also be used on

sumac and similar materials by varying the method of operation. In using this extractor, the stem *e* is connected to a copper or glass flask and the cap *d* to a condenser. The cock *f* and side openings *h* and *j* are closed. The material is weighed or washed in after covering the perforated plate at the bottom with a thin layer of cotton or filter paper, and then thoroughly moistened. A liter of water is placed in the flask, the apparatus connected up with the flask and the condenser, and heat applied to the bottom of the reservoir. The lower side opening *h* is opened, and the first portions of the extractives are collected there. After the strong extractives have been removed, the side opening is closed and the cock *f* opened, and a cumulative extraction continued until extraction is complete.

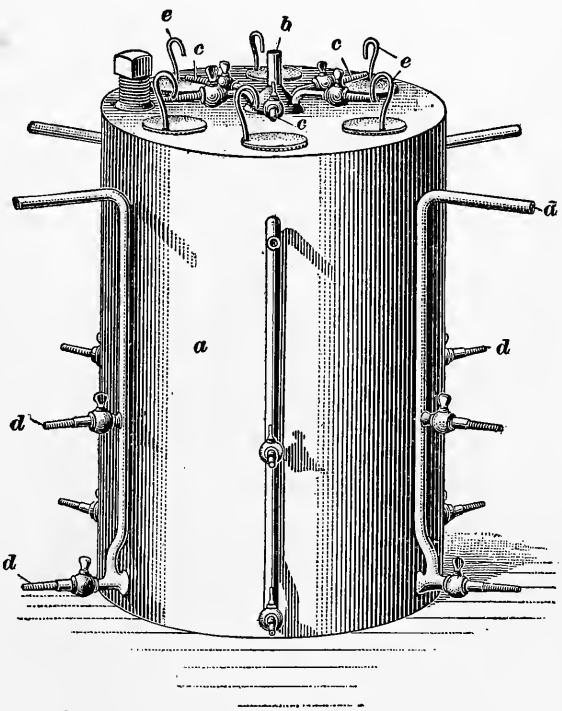


FIG. 6

29. In extracting sumac and similar materials, which must have cooler initial extraction temperatures, the cap can be left off and water at the desired temperature allowed to drip on the material, collecting extractives at either side opening. When the strong portions have been removed, the cap is replaced, connected with the condenser, the side openings closed, the cock *f* opened, and the extraction completed with steam from the flask connected to the stem *e*. The materials mentioned may also be extracted by covering them with cold water almost to the level of the upper side opening, connecting with condenser and reservoir, boiling the water in the reservoir slowly, and collecting the first portions at the *upper* side opening *j*.

When the desired amount of extractives is thus removed, the side opening is closed, the cock *f* opened, full heat applied to the reservoir, and extraction completed.

In all cases where strong extractives are removed from the apparatus, they should be mixed while hot with the weaker extractives that have accumulated in the reservoir, the entire extraction allowed to cool, made up to 1,000 cubic centimeters, and the analysis proceeded with.

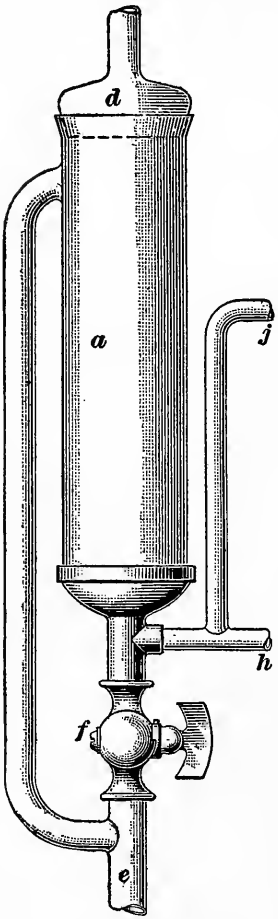


FIG. 7

30. Remarks Regarding Determinations to Be Made.—Three determinations, the *total solids*, *soluble solids*, and *non-tannins*, are made in a tannin analysis, and from the results the *insolubles*, or *reds*, and the *tannins* are obtained. The difference between the total-solids figure and the soluble-solids figure gives the amount of insolubles, or reds. By subtracting the non-tannin results from the soluble-solids results, the amount of tannins in the liquor is obtained. It is not necessary to dwell on the definition of these terms, but a few words on some of their constituents will not be amiss.

31. The reds, or insolubles, have been defined under tanning materials. Because of their greater or less solubility in warm liquor, it is necessary that the analysis should always be made when the liquor has a temperature of from 60° to 70° F. If colder, the reds figure will be higher and the subsequent tannin result lowered; if warmer, the reds will decrease and the tannin content increase.

Under non-tannins are classed all soluble substances in the liquor not absorbed by hide. For the most part, the non-tannins consist of sugary substances derived from the sap of the tree. In the same manner, under tannins are included

all soluble substances that will combine with hide, thus embracing all the forms of tannic acid.

32. Determination of Total Solids.—When the liquor, extracted and prepared as has been described, has cooled to 20° C., the cylinder *a*, Fig. 7, is shaken and allowed to stand for ½ hour; this is to allow small particles of bark to settle, so they will not be counted as reds, or insolubles proper. At the expiration of ½ hour, remove with a pipette 100 cubic centimeters of the liquor, place in a weighed glass crystallizing dish, and evaporate to dryness in a combined evaporator and dryer. Cool in a desiccator and weigh. From this weight the percentage of total solids is determined.

33. Determination of Soluble Solids.—To determine the soluble solids, place 1 gram of kaolin in a beaker and add 75 cubic centimeters of the tannin solution. Stir and pour on a pleated filter paper, collecting the filtrate in a clean beaker. Then return the filtrate to the paper for 1 hour, keeping the filter full. At the expiration of 1 hour, remove any of the solution remaining in the funnel and throw away both the solution and the filtrate. Refill the filter with the tannin solution, and as soon as the filtrate runs clear, collect it in a clean, dry beaker and remove 100 cubic centimeters for evaporation and drying. The kaolin should be previously washed with hydrochloric acid, then with distilled water, and finally dried and pulverized. It is used as an aid in filtering, forming a thin film over the paper, thus insuring a clear filtrate. The paper and kaolin absorb tannin from the solution, so that the affinity of these for tannin must be satisfied by allowing them to be in contact with the tannin solution for 1 hour before filtering the solution to be collected for drying and weighing.

34. Preparation of Hide Powder for Determining Non-Tannins.—To determine the non-tannins, hide powder is used. Hide powder is made by liming and depilating selected steer hides, neutralizing the lime remaining in the hide, and washing out the excess of acid with water. The

hide is then slowly and carefully dried without heat, and, when dry, it is ground about as fine as sawdust.

To prepare hide powder for use, the almost universal practice is to chrome it slightly. The chroming treatment increases the rapidity of absorption of the tannins, and by combining with the chrome-tanning materials the soluble portions of the hide substance are rendered insoluble. The American method of chroming is first to soak the dry hide powder overnight in water and then squeeze out the soak water through a linen cloth. Fresh water approximating twenty-five times the weight of the dry hide powder is added, and chrome alum (in solution) to the amount of 3 per cent. of the weight of the dry hide powder is added and thoroughly mixed. The mixture is frequently stirred during the day, allowed to stand overnight, and washed the next morning by alternately squeezing through a cloth and adding fresh water until the wash water is free from sulphates. When thoroughly washed, the mass is placed in a press and squeezed until the wet hide contains between 70 and 75 per cent. of water. It is then ready to be used for detannizing the tannin solutions.

35. Determination of Non-Tannins.—For the non-tannin determination, measure 200 cubic centimeters of the bark liquor into a strong glass tumbler, such as is used with a milk-shake machine, and after weighing 20 grams of the wet hide, place the liquor in the steam oven and dry it for moisture determination. Weigh out from the press the amount of wet hide necessary for the determination of non-tannins. Place this in the liquor, breaking up the lumps with a glass rod, and then shake the solution thoroughly. The shaking may be done by hand, using a tin cap such as is used for mixing drinks, or by a hand- or power-driven milk-shake machine. Shaking for 5 minutes on a milk shaker is sufficient for the hide powder to absorb every trace of tannin from the liquor. After shaking, add about 2 grams of kaolin and filter the solution through double filter paper. When the filtrate is running clear, collect, and with a pipette remove 100 cubic centimeters to a crystallizing dish; evaporate, dry, and weigh

in the same manner as when the percentage of solids was determined.

The amount of hide powder to be used depends on the strength of the bark liquor. In the case of unleached materials, the amount of sample extracted and the proportion of extraction water should be such as to give between .35 and .45 gram of tannin per 100 cubic centimeters of extractive solution. If these specifications have been carried out, an amount of wet hide powder representing from 12 to 15 grams of the dry powder should be used for 200 cubic centimeters of solution. In extracting spent materials, it is seldom found possible to procure an extractive solution that will contain .35 to .45 gram of tannin per 100 cubic centimeters, but the proportion should be approximated as closely as possible, and the quantity of hide powder used should be decreased accordingly.

Whether or not enough hide powder has been used, can generally be judged by the appearance of the non-tannin filtrate; if clear and white or pale yellow, the tannin has probably been removed. If the filtrate has a red or brown tinge, it is generally safe to assume the presence of some tannin. Doubtful filtrates should be tested with a 1-per-cent. gelatine to 10-per-cent. salt solution, cloudiness indicating the presence of tannin.

36. Calculation of Results of Bark Analysis.—Divide the weight of the total-solids residue by the number of grams of bark taken, and divide this result by the percentage of actual bark in the sample, found by subtracting from 100 the percentage of moisture, as determined in a 10-gram moisture sample. This result, when pointed off to correspond to the decimal part of the original liter, is the percentage of total solids. The percentage of total soluble solids is found in the same manner.

Because of the water added by the wet hide used in the non-tannin determination, a correction must be made. If the 20-gram sample of wet hide powder when dry weighs only 6 grams, there are 14 grams of water added to the liquor for every 20 grams of wet hide used. If 40 grams of wet hide is

used, there are 28 grams of water added, and the volume then becomes 228 cubic centimeters instead of the 200 cubic centimeters originally taken; 100 cubic centimeters of the diluted filtrate has been dried, and it accordingly represents only $\frac{100}{114}$ of the actual amount of non-tannins, so the weight must be multiplied in this case by 1.14. Therefore, to calculate the percentage of non-tannins, divide the non-tannin weight successively by the number of grams of bark taken and the percentage of dry bark, as under the solids calculations, and multiply this result by the hide-moisture correction.

ILLUSTRATION.—For the analysis, 25 grams of bark were taken and 40 grams of wet hide powder were used. The bark contained 12 per cent. of moisture and 88 per cent. of dry bark. A 20-gram sample of wet hide when dried weighed 7 grams. The 40 grams of hide used, therefore, contained 14 grams of dry hide and 26 grams, or cubic centimeters, of water, which latter was added to the original 200 cubic centimeters.

$$\frac{200+26}{200}=1.13, \text{ or the hide-powder correction for moisture}$$

	GRAM
Total-solids residue weighed	.4983
Total soluble-solids residue weighed	.4012
Non-tannin residue weighed	.1441

For the total-solids determination, 100 cubic centimeters of liquor was taken, or .1 of the liter. The calculation would be as follows:

$$\frac{.4983\times100\times10}{25\times.88}=22.65 \text{ per cent. of total solids}$$

The total soluble solids are calculated in the same manner.

$$\frac{.4012\times100\times10}{25\times.88}=18.24 \text{ per cent. of total soluble solids}$$

The total solids less the total soluble solids give the amount of insolubles.

$$22.65-18.24=4.41 \text{ per cent. of insolubles}$$

For the determination of non-tannins, 100 cubic centimeters, or $\frac{1}{10}$ liter, of liquor was dried. The hide-powder correction was found to be 1.13. The calculation would be as follows:

$$\frac{.1441\times100\times10\times1.13}{25\times.88}=7.40 \text{ per cent. of non-tannins}$$

The total soluble solids less the non-tannins give the amount of available tannin.

$$18.24-7.40=10.84 \text{ per cent. of available tannin}$$

The complete analysis is as follows:

				Per Cent.
Total solids	Total soluble solids	Non-tannins	7.40	
		Tannins	10.84	18.24
	Reds, or insolubles		4.41	22.65
Insoluble parts of bark (not removed by leaching)				77.35
Total				100.00

This would be reported as follows:

	Per Cent.
Moisture	12.00
Total solids	22.65
Soluble solids	18.24
Non-tannins	7.40
Tannins	10.84
Reds (or insolubles)	4.41

37. The figures in the preceding illustration are, of course, on an absolutely dry basis. If it were desired to report the results on the commercially dry basis, simply multiplying the absolutely dry figures by .88 would give the commercially dry figures. The sample having contained 12 per cent. of moisture, there would, of course, be 88 pounds of absolutely dry bark in every 100 pounds of the commercial article.

It is customary to report fresh-bark results on the absolutely dry basis, and then give the tannin figure also on the commercially dry basis. Spent-material results should be reported on the dry basis and cannot really be reported on the commercial basis unless the analysis of the original new material is known. This is because a considerable portion of a new bark is removed by the leaching process, and the analysis of the spent bark is not on the same basis as to bark weight as was the analysis of the original new bark. Taking this into account and figuring back the results to the same basis, the commercially dry tannin figure of a spent tan analysis is found to be about 77 per cent. of the absolutely dry tannin figure.

ANALYSIS OF TANNING EXTRACTS

38. The exact conditions to which an extract analysis must conform, in order that it may be said to have been made by the Official Method, are set forth annually in the report of the American Leather Chemists' Association, which comprises practically all the leather chemists of the United States. As now carried out, the method is to dissolve a quantity of the extract as will give from .35 to .45 gram of tannin per 100 cubic centimeters of solution in 900 cubic centimeters of water at 80° C., making up to the liter mark after standing not more than 20 hours and not less than 12 hours. The temperature of the solution must not go below 20° C.

39. Total Solids.—Mix the solution thoroughly, and pipette 100 cubic centimeters into a tared glass dish. Evaporate, dry, and weigh.

40. Soluble Solids.—Place 1 gram of acid-washed kaolin in a beaker and add 75 cubic centimeters of the solution. Stir and pour on a No. 590 S. & S., 15 centimeters, pleated filter paper. Return the filtrate to the paper for 1 hour, keeping the filter full. At the expiration of 1 hour, pour the remaining solution from the filter or remove with a pipette. Then refill the filter with another portion of the solution brought to a temperature of 20° C., and begin to collect the filtrate as soon as it runs clear. Pipette 100 cubic centimeters of the clear filtrate into a tared glass dish, and evaporate, dry, and weigh. The funnels and receiving vessels should be covered to guard against evaporation.

41. Non-Tannins.—Add to 200 cubic centimeters of the solution a quantity of wet hide powder representing from 12 to 15 grams of dry hide. Shake for 10 minutes and squeeze immediately through a linen cloth. Add 2 grams of kaolin to the filtrate, stir, and filter through a folded filter of size sufficient to hold entire filtrate, returning the filtrate until it is running clear. Evaporate and dry 100 cubic centimeters of this filtrate. The hide powder is to be prepared as previously

described, and the non-tannin filtrate should be tested for tannin if its presence is suspected.

42. Calculation of Results of Tanning-Extract Analysis.—The results are calculated by dividing the different weights by the amount of extract taken and pointing off for the percentage basis, not forgetting the hide-moisture correction on the non-tannin weight.

ANALYSIS OF TAN LIQUOR

43. Determination of Specific Gravity and Total Solids.—Shake the sample well and with a barkometer determine its specific gravity in degrees barkometer. As a general rule, 1° barkometer represents .25 per cent. of total solids, and by applying this rule, the amount of liquor to be taken to make the proper dilution for analysis may readily be computed. The liquors should be diluted so that 100 cubic

TABLE II

AMOUNT OF HIDE POWDER REQUIRED FOR DIFFERENT TANNIN STRENGTHS

Tannin Range per 100 Cubic Centimeters	Dry Hide Powder per 200 Cubic Centimeters
.35 to .45 gram	8 to 10 grams
.25 to .35 gram	5 to 8 grams
.15 to .25 gram	2 to 5 grams
.00 to .15 gram	0 to 2 grams

centimeters of the diluted liquor will give a residue approximating .7 gram in weight. The water used for dilution should have a temperature of 70° F. After thoroughly mixing the diluted liquor, the total solids, soluble solids, and non-tannins are determined as under Analysis of Tanning Extracts. Since the dilution varies with the gravity of the liquor, the tannin strength of the different diluted liquors is not the same, and different amounts of hide powder are used, depending on the tannin content of the liquor.

Table II shows what is believed to be the proper amounts of hide powder to be used for different tannin strengths.

For convenience in calculating results, it is best to dilute the liquors to the volume of 1 liter. When thus diluted, the weights of the different residues divided by the number of cubic centimeters of liquor diluted to 1 liter will give a result that only needs proper decimal pointing to indicate the percentage of each item. The moisture correction for the hide powder must be applied to the non-tannin weight.

44. Determination of Total Free Acids.—There are several methods in use for the determination of the total free acids, but none is above criticism and results are comparative rather than absolute.

Charcoal Method.—To 100 cubic centimeters of the diluted liquor used for the determination of the tannin, add 2 grams of chemically pure animal charcoal. Stir frequently during a period of 2 hours, strain on a dry filter, and titrate an aliquot portion with decinormal alkali, using phenol-phthalein indicator.

Or, to 100 cubic centimeters of the diluted liquor in a flask with a tube condenser add 2 grams of the charcoal. Heat to boiling with frequent shaking; then cool, filter, and titrate an aliquot portion.

Quinine Method.—Dilute 50 cubic centimeters of original liquor to 500 cubic centimeters. To 200 cubic centimeters of the diluted liquor, add 20 cubic centimeters of quinine solution. Mix thoroughly and filter. Take 100 cubic centimeters of the filtrate and titrate with decinormal alkali and phenol-phthalein indicator. Multiply the number of cubic centimeters used by .066 to obtain direct the percentage of acid, as acetic acid, in the original liquor.

The quinine solution is made by dissolving 15 grams of quinine (pure alkaloid) in 110 cubic centimeters of 95-per-cent. alcohol that has previously been neutralized. To this, add slowly while stirring 90 cubic centimeters of distilled water, so as to bring the volume up to 200 cubic centimeters.

Lime-Water Method.—Titrate 20 cubic centimeters of the original liquor, filtered, with twentieth normal lime water.

The end point is indicated by the beginning of turbidity, when sufficient lime water has been added. Some chemists put the filtered liquor in a flat 2-ounce panel bottle, in which the panels are very close, and then titrate, holding the bottle against a strong light.

45. Determination of Combined Sulphuric Acid. In acid tanneries, a determination of the free and combined sulphuric acid present in the liquors is frequently required. To determine the combined sulphuric acid, evaporate 100 cubic centimeters of the original liquor in a platinum dish and char the residue at a very low red heat. Cool, add hydrochloric acid and hot water, filter, and determine the sulphates in the filtrate with barium chloride, as explained in Quantitative Analysis.

To determine the total sulphuric acid, take 50 cubic centimeters of the original liquor, add distilled water and a little hydrochloric acid, bring to a boil, and precipitate the sulphuric acid with barium chloride. The difference between the percentages of total acid and combined acid will be the approximate free sulphuric acid in the liquor.

When the amount of free sulphuric acid only is required, a more accurate method is to evaporate 100 cubic centimeters of the liquor on a steam bath and digest the residue with absolute alcohol, determining sulphuric acid in the alcohol after digestion.

46. Bleach Liquors.—It is frequently desirable to know the amount of material removed from leather by the *bleach* baths. The following method gives fairly accurate figures:

Take samples of all baths before starting the day's work and at the close of the day. Evaporate and dry 50 cubic centimeters of each sample, weigh, and subtract the combined *morning* percentages from the combined *evening* percentages. Multiply the difference in percentages by the weight of water in a single vat, and from the result subtract the weights of soda and acid added during the day (acid weights should be taken at 100 per cent. and sal soda weights at 40 per cent. actual solids). The remainder will be the approximate amount of

organic material removed in all the vats. When this figure is divided by the number of sides bleached, the amount of solids removed from each side of leather will be obtained.

A method of determining the amount of tanning material removed by the soda vat is to evaporate and dry 50 cubic centimeters of the liquor in a platinum dish, weigh, and then char the contents, break up the charred mass, add hot water and titrate. The difference between the weight of the dried residue and the weight of the alkali (figured in its form at the drying temperature), will give the organic matter in 50 cubic centimeters, and knowing the size of the vat and the number of sides bleached, the amount removed per side may be readily calculated.

ANALYSIS OF LEATHER

47. For many reasons, it is frequently desired to determine quantitatively the constituents of different leathers, and while the analysis of leather is not difficult, yet, in order that different analysts may secure concordant results, it is necessary for them to follow identical methods in determining the composition of leather.

The samples should be taken from different parts of the side of leather, since different portions of the leather will show a difference in composition, because of the difference in the thickness and texture of the hide. The belly and flank, being softer than the back, will make leather of an entirely different composition from that of samples taken from the back of the same side of leather.

The samples are prepared by grinding, or by shaving with a carpenter's plane, or by the use of a coarse wood rasp. The finely divided leather should be well mixed and stored in a stoppered glass jar.

48. Determination of Moisture.—In determining the amount of moisture present, 10 grams of the ground leather should be dried for 1 hour in an oven at a temperature of 105° C. This period of time will generally suffice to drive off moisture from most samples, but occasional samples require a

longer time. After taking the dry weight, it is well to replace the sample in the oven and subject it to a further drying of 15 minutes, weighing it again in order to verify the dry weight originally obtained.

49. Determination of Ash.—For the determination of ash, 15 grams of the ground leather should be burned in a platinum dish. The leather should be slowly heated until all volatile matter is driven off; then the charred mass may be broken up and the ignition concluded.

Mineral adulterations will be indicated by the analysis of the ash, and these are determined by a quantitative examination of the residue. Epsom salts are quite commonly used for brightening and tempering leather and also for adulteration, and if this material is the only constituent of the ash to be sought, its presence may be quickly determined by dissolving the ash in hydrochloric acid, precipitating iron and alumina with ammonia, and filtering. After precipitating and filtering off the lime, the magnesium is determined in the cooled filtrate by precipitation with sodium-ammonium phosphate.

50. Determination of Oil.—To determine the oil and grease in leather, a 15-gram sample is extracted in a glass Soxhlet extractor for 3 hours, using about 100 cubic centimeters of petroleum ether as a solvent. The petroleum ether should be tested by evaporating 100 cubic centimeters in a tared dish and weighing any residue. The oil extraction should be conducted by heating the flask on a steam bath, so that there shall be a constant ebullition of the petroleum ether and a steady drip of the condensed vapor falling on the leather in the Soxhlet apparatus. When extraction is complete, pour the ether (which should now contain the oil and grease originally in the leather) into a tared, glass crystallizing dish, rinsing out the flask with a little additional petroleum ether. After evaporating the ether, the oil residue remaining in the crystallizing dish is dried and weighed. To determine the nature of the oils or greases used, a larger quantity of the leather must be extracted in order that the oil residue may be sufficiently large to admit of qualitative and quantitative examination.

51. Determination of Nitrogen.—The amount of hide substance in a leather is found by first determining the percentage of nitrogen in the sample. From this figure the percentage of hide contained in the leather is calculated by dividing by the factor .178. This factor is generally agreed on as the result of many analyses, which showed the average nitrogen content of hide substance to be 17.8 per cent.

To determine nitrogen in leather, the oil in the leather must first be extracted, as the presence of fatty oils or greases would, of course, give a fictitious nitrogen result. It is convenient to dry the residue from the sample used for determining the oil, making the nitrogen determination on this dried, oil-free sample. The method is practically the well-known Kjeldahl nitrogen method, some slight modifications being made in its operation. Of the dry, oil-free sample 1.5 grams is weighed into a Kjeldahl flask, and 20 cubic centimeters of strong sulphuric acid and 1 drop of metallic mercury added; the mercury is added to help in the oxidation of the carbonaceous matter. A loose-fitting, hollow balloon stopper is placed in the neck of the flask, and the flask is then held in a sloping position over a low flame that is gradually increased, and the contents are allowed to boil slowly until nearly colorless. While still hot, drop in crystals of potassium permanganate until the solution remains slightly purple. Then transfer it to a distilling flask with 300 cubic centimeters of water, add 25 cubic centimeters of potassium-sulphide solution (40 grams to liter), and connect the flask with the water condenser, being careful to have all joints absolutely tight.

The distilling flask should be provided with a double-perforated stopper, one perforation for the tube leading to the condenser, and the other for the stem of a separatory funnel. After passing through the water-jacket, the delivery tube should be connected by means of a tight-fitting, perforated cork, to one leg of a large, bulbed **U** tube containing 50 cubic centimeters of $\frac{N}{1}$ sulphuric acid. The **U** tube is set in a larger beaker about half full of cold, neutral, distilled water. After connecting the distilling apparatus, a strong solution of sodium

hydroxide is placed in the separatory funnel, and by gradually opening the cock, an excess of the solution is run into the flask and the cock closed. Heat is then applied to the flask and slow distillation continued for about 30 minutes. The ammonia released by the addition of the alkali passes over through the condenser and is absorbed by the $\frac{N}{1}$ acid in the **U** tube. When the distillation is complete, the acid in the **U** tube is titrated back to neutrality with $\frac{N}{1}$ ammonia, using cochineal as an indicator. The water in which the **U** tube has been immersed should always be titrated in case the **U** tube has overflowed. The amount of standard ammonia used in the titration, deducted from 50 cubic centimeters, gives the quantity of acid neutralized by the ammonia from the leather, each cubic centimeter of which corresponds to .017 gram of ammonia, or .014 gram of nitrogen. The percentage of nitrogen divided by .178 gives the percentage of hide fiber in the leather.

The reagents used must be free from ammonia, and a blank test, using sugar, should be made, making correction, if necessary, on subsequent determinations of nitrogen in leather.

52. Determination of Water-Soluble Materials.—The estimation of the amount of water-soluble materials in leather presents the only mechanical difficulties encountered in the extraction of the leather. The total amount varies with the period of extraction, although after a certain time the remaining solubles are not appreciable. The ground leather may be extracted by simple digestion with successive quantities of water at 40° to 50° C., squeezing the mass in a linen cloth after each digestion and then adding fresh water. This kind of extraction results in a large volume of weak extractive solution, which is sometimes concentrated by boiling, so that the entire volume is reduced to 1 liter. If only the total amount of water solubles is desired, this procedure is not objectionable; but when the constituents of the water-soluble matters are to be determined, concentration by boiling should be avoided. Probably the best method of extraction is to digest the sample three or four

times with water at from 40° to 50° C., then transfer the mass of leather to a glass Soxhlet, and complete the extraction, uniting the extractives secured by the two methods. The boiling temperature necessitated by the Soxhlet extraction will cause the leather to run together and form a sticky mass, through which the extracting water can pass only with difficulty. This may be prevented to some degree by mixing the leather with several times its volume of sand before placing it in the extractor. For the water-soluble determination, 20 grams of the sample should be extracted, as just outlined, and the extractive solution brought to a liter in volume. This is then analyzed for tannins and non-tannins, according to the methods of tan-liquor analysis previously described.

53. Determination of Glucose.—Glucose in leather is determined in the water-soluble material by Fehling's solution after removing the tannin. The tannin is removed by basic lead-acetate solution, which is made as follows: 300 grams of lead acetate is mixed in a liter flask with 100 grams of litharge and 50 cubic centimeters of water. The flask is then heated on a boiling-water bath until the mixture is nearly white, more water being put in the flask to replace that which has evaporated. The mixture is then digested with 1 liter of cold water and filtered.

The lead-acetate solution having been made, 20 grams of the leather is digested with successive small portions of water, filtering after each digestion through a cotton plug stuck in the neck of a funnel. The temperature of the extracting water should be gradually increased from 40° C. for the first digestion to boiling water for the last two digestions. The extractive solution should amount to 500 cubic centimeters, and after cooling, 30 or more cubic centimeters of the basic lead-acetate solution is added, well mixed by shaking, allowed to stand for 15 minutes, and then filtered through a dry filter, collecting exactly 400 cubic centimeters. To the 400 cubic centimeters of filtrate add 30 cubic centimeters (or more if necessary to throw out the lead) of a strong magnesium-sulphate solution, shake, and filter on a dry filter. Boil

100 cubic centimeters of this filtrate with 3 cubic centimeters of strong hydrochloric acid for 3 hours, not allowing the volume to go below 75 cubic centimeters. This is for the purpose of inverting unconverted dextrin and intermediate products, which are generally present in commercial glucose and which, unless inverted, are not determined by Fehling's solution.

After boiling, make the solution slightly alkaline by the addition of a concentrated sodium-hydroxide solution; make up to 100 cubic centimeters and filter if necessary. Transfer the solution to a clean burette and use it to titrate 10 cubic centimeters of Fehling's solution. For this operation 5 cubic centimeters of each of the Fehling solutions are placed in a casserole, 40 cubic centimeters of water added, and the whole brought to a boil. Run in from 5 to 10 cubic centimeters of the sugar solution at a time, boiling the liquid 2 minutes between each addition, until the blue color has nearly disappeared. The sugar solution should then be added in smaller quantities and the time of boiling reduced to $\frac{1}{2}$ minute between each addition from the burette. The end point may be determined by the absence of blue color on looking through the supernatant liquor, or potassium ferrocyanide may be used as an indicator. If the indicator is used, take a few cubic centimeters of the solution, run through a very small filter, and add a little acetic acid and 1 drop of potassium-ferrocyanide solution.

54. It is well to make an approximate titration at first and then a second titration on another 10 cubic centimeters of Fehling's solution, adding nearly the whole of the required sugar solution at once, so that the time of boiling and titration is reduced to a minimum. Fehling's solution, of which 10 cubic centimeters equals .05 gram of glucose, is made in two parts as follows:

In making solution 1, dissolve 34.6 grams of pure crystallized copper sulphate in distilled water, then add 10 cubic centimeters normal sulphuric acid and make up the whole to 500 cubic centimeters.

In making solution 2, dissolve 125 grams of chemically pure potassium hydroxide and 173 grams of pure potassium sodium tartrate (Rochelle salts) in distilled water and make up to 500 cubic centimeters.

To make Fehling's solution, 5 cubic centimeters of each of these solutions are mixed just before using.

A convenient strength of the magnesium-sulphate solution is made by titrating 10 cubic centimeters of the basic lead-acetate solution with a strong solution of magnesium sulphate until no further precipitate is produced. One hundred times the quantity of sulphate solution needed for the titration is made up to a liter, and the use of this solution will result in the removal of the lead without a large residual excess of magnesium sulphate.

MANUFACTURE OF LEATHER

(PART 3)

Serial 416C Edition 3

LIMP, OR LIGHT, LEATHERS

PROCESS OF MANUFACTURE

1. Introduction.—In order to make a soft and pliable product known as *limp,* or *light,* leather, the hides or skins used require very much different treatment from that given to the hides in the manufacture of sole leather. The actual tanning for certain classes of leather is conducted along the same general lines as in the making of sole leather, but with weaker liquors and covering a shorter period of time. With these pliable leathers the tanning is really the smallest part of the manufacturing process, as the finishing of the leather requires a larger proportion of time and labor. The tanning, however, whether it be vegetable, mineral, or oil, must be suited to the use for which the leather is intended, as no amount of skilled finishing can entirely obliterate the defects of an improperly tanned hide. Because of the multiplication of operations in making light leathers, processes of manufacture differ to a greater extent than in the tanning process for heavy leather. Every light-leather tanner aims to attain the same result, but methods differ in each department of different tanneries; and nearly every tanner uses methods and formulas differing slightly from the methods and formulas of his competitors.

As they appear on the market, limp, or light, leathers

COPYRIGHTED BY INTERNATIONAL TEXTBOOK COMPANY. ALL RIGHTS RESERVED

may have been made from whole hides or skins, or they may have been made by splitting heavy hides into a number of lighter pieces, or **splits**. The tannage of these hides, splits, or skins varies according to whether they are to be used for automobile leather, shoe leather, bag and strap leather, fancy leather, or glove leather. No general description can be given to include all classes, although some of the steps may be similar for the different grades.

In discussing light leathers each class will be taken up individually and, when possible to do so, reference will be made to like treatment in other branches of the industry.

As Part 1 deals entirely with heavy leather of vegetable tannage, we will first consider the light leathers which are also of vegetable tannage, and then follow with mineral and oil tannages.

AUTOMOBILE AND UPHOLSTERING LEATHERS

2. General Preparation.—In making leathers for automobile, carriage, and other upholstering purposes, the heaviest and most spready of green salted hides are used, in order to make one hide cover the greatest possible surface. Swiss and Paris hides are popular for such purposes, and hides from these sources are largely made into leather for this class of work. The hides are soaked, fleshed, limed in straight lime solutions, unhaired, and bated. (See Part 1.)

The bating of hides for automobile leather should be very complete, as the stock must be in as soft and open a condition as possible. Formerly manure bates were employed, but today either oropon, a material composed of ammonium chloride, wood fiber, and dry pancreas, or puerine is used. In using oropon, the paddle is about three-fourths filled with water at a temperature of 95° F. and about one-half of one per cent. of oropon on the weight of the stock is introduced. While the paddle is running, the hides are entered and the stock turned until all lime has been removed. The grain will

by this time have assumed a silky condition and the fiber is probably well separated.

In order to set the grain, secure a good, even color and obviate the danger from kiss spots, the stock is usually transferred from the bate to a spent tan liquor made acid with a small quantity of either an organic or a mineral acid.

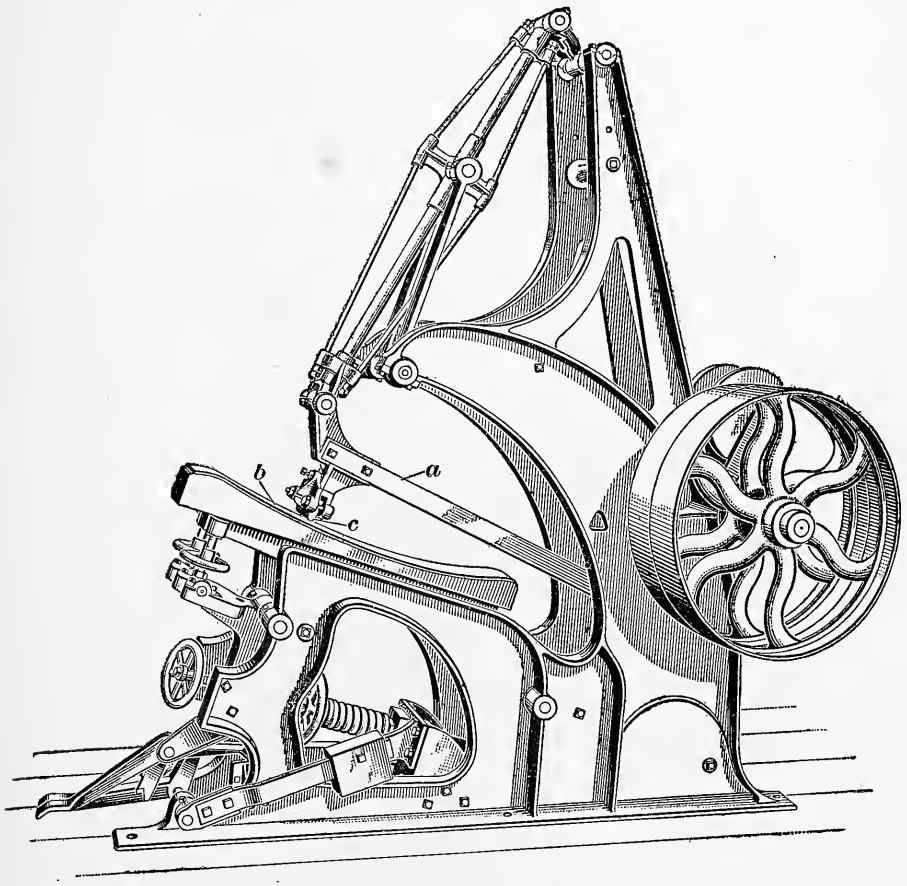


FIG. 1

When ready for tanning, the hides are hung by the butt on a rocker frame and rocked in the tan liquor. The hides go into the weakest liquor, the stronger liquor gradually working through the section of rockers until the leather receives the strongest liquor and is sufficiently tanned for the splitting machine. The tanning liquor is composed of a combination of two or more tanning agents, such as hemlock, oak, quebracho, gambier, and palmetto. When the leather is suffi-

ciently tanned, the hide is run through a wringer, or piles of them are pressed in a hydraulic press, to remove the excess of tan liquor previous to splitting. They are worked on a stoning jack to remove wrinkles and to smooth out the surface.

3. Stoning Jack.—The **stoning jack,** shown in Fig. 1, is built of iron and is run by a side-belt drive. By means of a crank-shaft, an arm *a* supported and guided by a swinging truss is given a backward and forward motion, following the contour of an inclined metal bed *b,* the face of which is smooth and cut in the form of a segment of a circle. To the end of the arm is attached the *stone c,* which is a rectangular piece of metal with rounded corners and slightly longer than the width of the bed. When in operation, this tool is carried backwards and forwards over the bed at a distance from it regulated by the operator by means of a foot-lever. The leather is thrown on the face of the bed, under the moving arm, and the stone brought down on it. By the action of the stone the wrinkles and creases are removed, the leather being moved around under the stone by the operator, so that every part comes in contact with the stone, or smoothing tool. The grain side is finally split, the split being made light or heavy, according to the purpose for which the finished leather is to be used.

4. Splitting Machines.—Two general classes of **splitting machines** are in use, the *Union splitter* and the *belt-knife splitter.* The latter is the more popular machine and is found in most of the Eastern upper-leather tanneries.

In the **Union splitter,** the leather is presented to the edge of the splitting knife by gripping and drawing rollers. It is held on the rollers by carrying arms and is split by the power that rotates the roller by which the leather is carried.

The **belt-knife splitter,** shown in Fig. 2, effects the splitting by means of an endless belt knife *a,* against which the leather is carried by means of rolls. Machines of this type are not automatic, but require skilled labor to operate them economically.

After having taken off the grain split the remainder of the hide passes under the eye of the inspector, who decides the number and weights of succeeding splits. The grain splits are then retained in revolving tight drums with quebracho

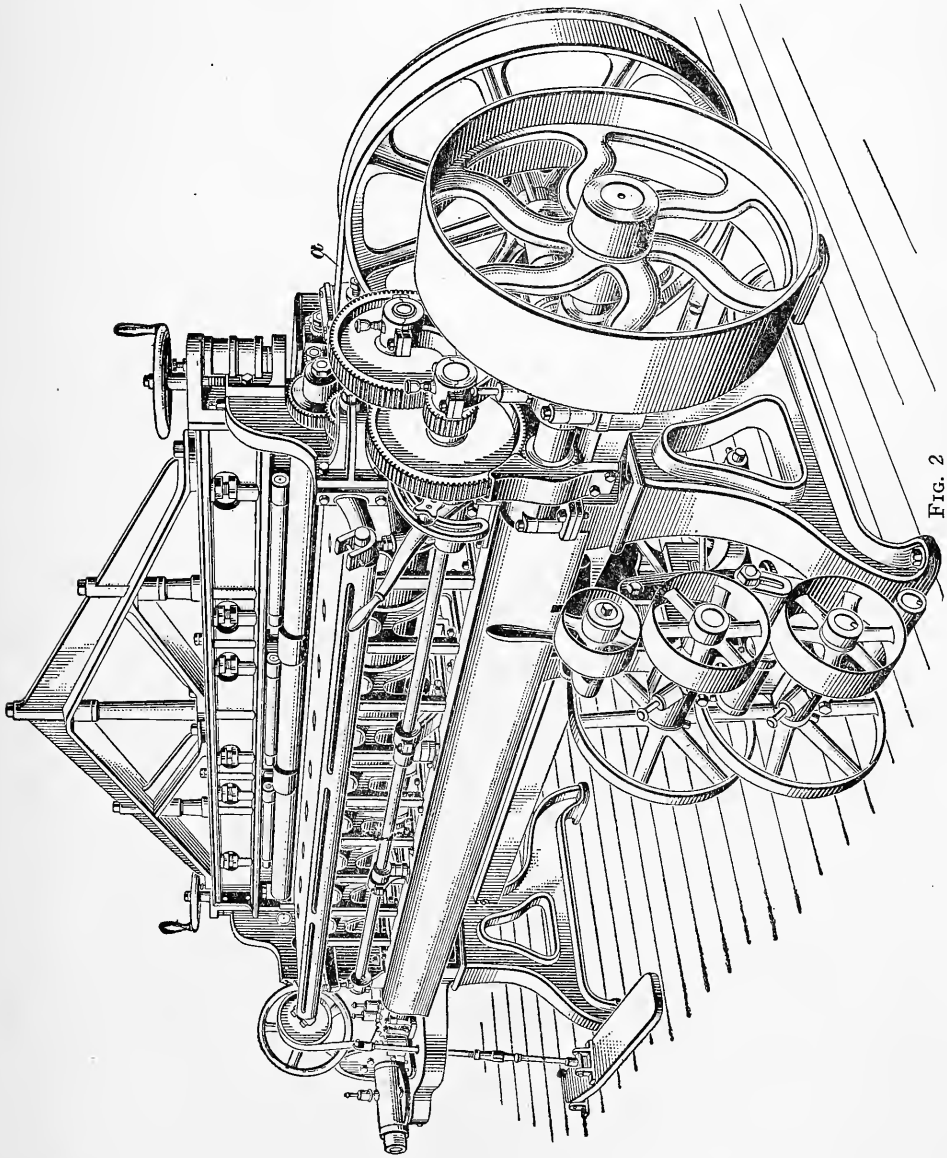


FIG. 2

and gambier liquors, the flesh splits being retanned in open vats, into which revolving paddle wheels dip.

After retanning, the splits are run into a wheel with sumac liquor, and after this treatment they are set out by hand or

by machine to remove the excess of water, and while on the table they are given a mixture of degras and cod oil. The leather is then closely tacked to heavy frames clamped in a stretching machine wherein the wet leather is stretched in all four directions. The frame is then tightly clamped to retain the stretch, and it is taken to the drying loft, where the leather dries, retaining the increased surface given it by the stretching. When dry, the splits are broken by hand or by machine to make them soft and pliable, and after buffing, if necessary, they are ready for an application of the coating. The grain splits are hand-buffed before being coated; machine buffing is also done by taking a very thin split from the grain.

5. Daubing.—The *daub,* or *coating,* for the leather is generally made by boiling down linseed oil with the desired pigment and thinning the mixture with naphtha. It is quite important that this daub should be properly made, and 2 days is generally required for the operation. The oil is boiled in a large kettle over a coke fire and constantly stirred. On the first day the temperature of the oil is run up to nearly 600° F. and then lowered to about 380° F. before it is left for the day. On the second day, the temperature is raised a little over 600° F., and the cooking is continued until the desired consistency is attained. The oil is gradually cooled, the fire extinguished, and naphtha added to thin the jelly-like residue; the naphtha is added in small portions with constant stirring. The highest grade of pigments that have been carefully ground in oil are thoroughly incorporated into the daub. All colors of coatings, different degrees of gloss, and varying thicknesses of the enamel are given to leather intended for different purposes.

The grains, splits, and buffings having been assorted and assigned to the different grades, weights, and classes of finished product, are stretched and tacked to frames and receive a heavy coat of the daub, which is carefully and evenly applied, the excess being removed. When the first coat has dried, a second coat is applied and the frames are placed horizontally in the drying oven, where the second coat is dried at a

temperature of about 120° F. When this second coat has dried, a thinner coat of the boiled oil is applied, and after this has dried, the surface is smoothed by rubbing with pumice stone. From four to eight coats of the bottom daub are applied, according to the requirements of the finished leather, and the drying may be done either in the air or in the oven, depending also on the future use of the leather. When the bottom coats have been applied and the surface smoothed, a coat of varnish and oil is applied and dried in the oven. This may be followed by smoothing and the application of a final coat of varnish and oil, and after drying in the oven, and a sun-and-air drying to remove the stickiness, the leather is taken from the frames, trimmed, and is then ready for the market. Some of the heavy leathers, as, for instance, the visors for military caps, are coated on two sides, each with a different color.

Various compositions other than boiled linseed oil are now being used for coating the leather, particularly for furniture, fancy embossed leathers and shoe leathers. Wood alcohol, amyl acetate, acetone, and other solvents are used as vehicles for carrying organic gums, pyroxylin, camphor, etc., in making up coats for shiny leather.

6. Furniture and ornamental leathers receive fewer coats than the heavier carriage dash and automobile leather, and they are given a grain either by boarding, by pebbling, or by the embossing press. The newer compositions for coating are frequently used on this leather.

The buffings, or grain splits from machine buffing, are very thin and are used for bookbinding and for covering boxes, etc. They are coated, colored, and surfaced and may be embossed.

The popular so-called *Spanish leather* that is now frequently used in upholstering for mission furniture is made by tanning the hides in strong quebracho liquor, which draws the grain and gives the leather its unique appearance. In finishing, it is dyed to the desired shade and coated so that the pigment fills the wrinkles in the surface and accentuates the irregular

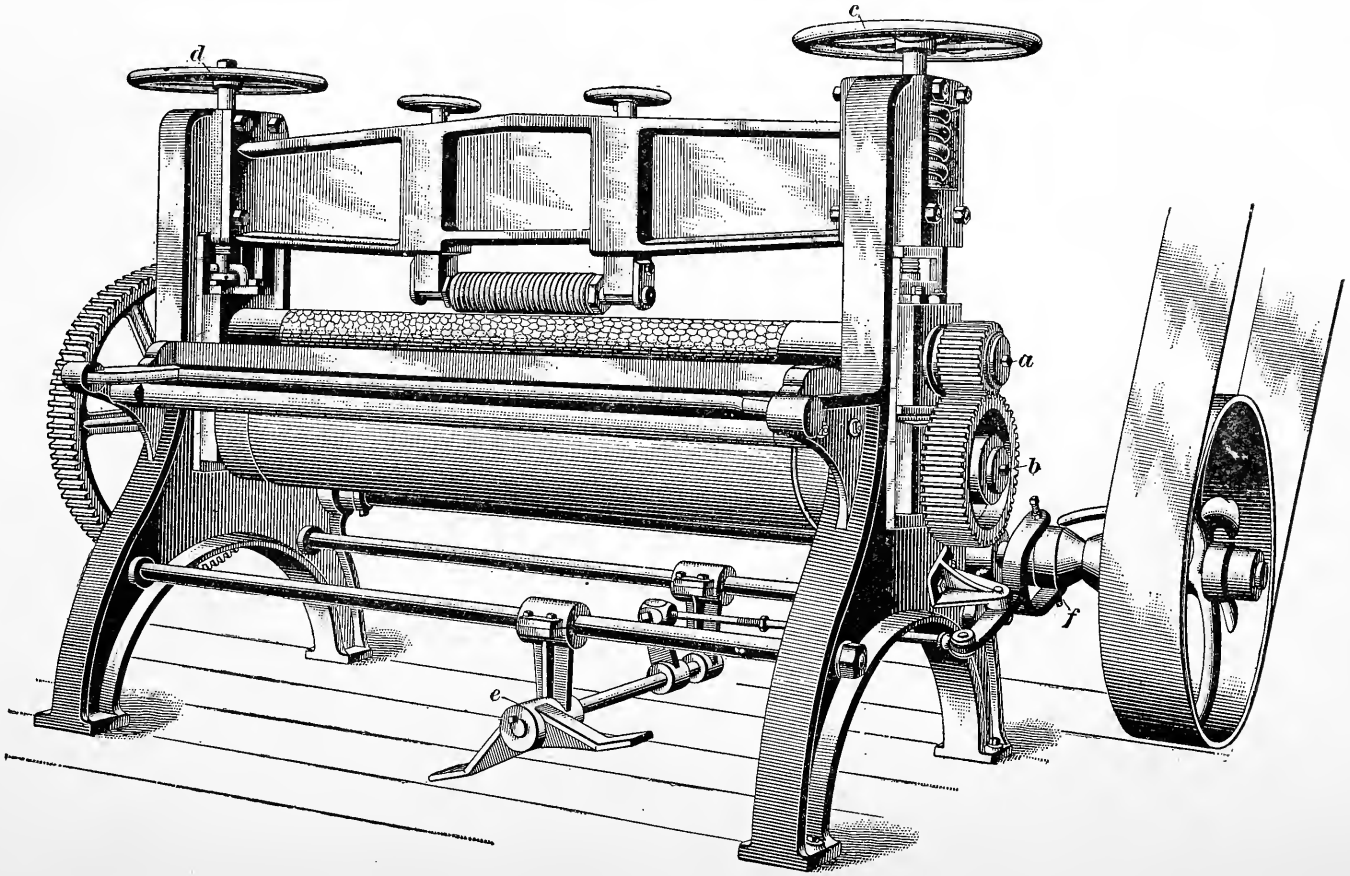


FIG. 3

grain. Spanish leather is also made by embossing the leather and then staining.

7. Embossing.—For embossing, a heavy pressure, distributed over a large area of leather, is needed. The embossing machine shown in Fig. 3 consists of two geared rolls *a* and *b*. The lower one *b* is smooth and forms a supporting surface for the leather that is to be embossed. The upper one *a* is smaller, and the design to be embossed is cut in its surface. The leather is fed between the moving rolls and receives the design from the upper roll. The pressure is regulated by hand wheels *c* and *d* at either end of the machine, and a foot-treadle *e*, connected with clutch *f* on the drive shaft, assures perfect control of the machine by the operator.

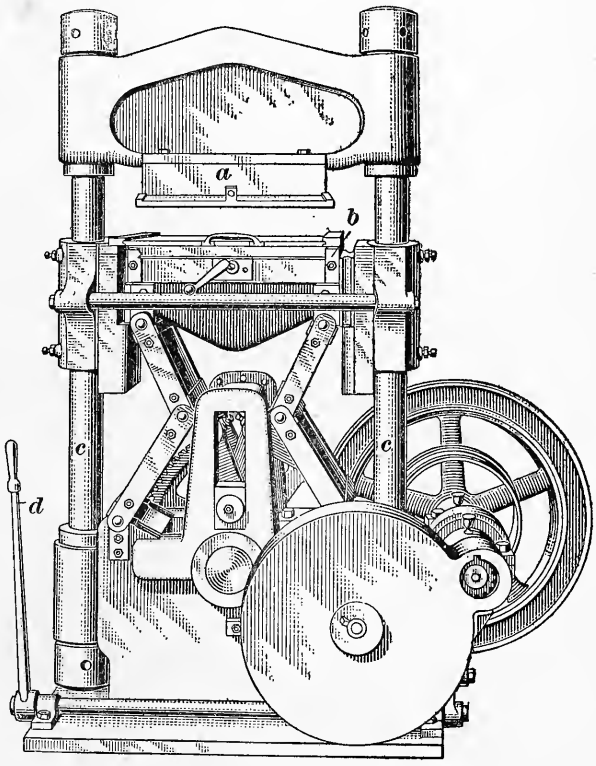


FIG. 4

8. A large proportion of the graining and embossing of leather is done by embossing presses similar to the machine illustrated in Fig. 4. A plate in which the pattern of grain or embossing desired on the leather has been cut is attached to and covers the bottom of the heated head *a*. The leather is laid on the bed *b*, and the lever *d* sets in motion the gears that raise the bed along the guide rods *c* until the leather comes in contact with the embossing plate on the head. The leather is subjected to enormous pressure, giving it the impression

of the particular pattern on the plate. The bed is then automatically lowered, and another portion of the leather is moved on the bed to receive the pattern. The head may be heated by gas, steam, or electricity.

BAG, CASE, AND STRAP LEATHER

9. Vegetable-tanned leather for bags and straps is made from green salted hides. The hides are soaked and split into sides after coming from the soaks. They are then limed, unhaired, fleshed, and bated. After bating, the sides are attached to sticks and go into the rockers. The rocker liquors contain sufficient fermentative acids to neutralize any lime not removed by the bate, and to plump the sides. The small amount of tannin present serves to color the stock and prepare it for the subsequent tan liquors. After the rocker treatment, the hides are moved to the weakest of a series of vats containing progressively stronger liquors. The hides are moved forwards throughout the series until the strongest vat is reached. After hanging in the last vat the required length of time, the tanning is completed to the required degree. The time required for the tanning varies in different yards, being as low as 15 days in some and as high as 30 days in others. As the sides are to be split, complete tanning is not necessary, but it is essential that the sides should be colored entirely through, so that the splitting knife will have a homogeneous substance on which to work. The liquors are made by combining hemlock and oak barks, myrobalans, chestnut, and quebracho extracts in proportions determined by cost, character of leather desired, and the ideas of the tanner.

10. After tanning, the sides are taken to the wringer and the excess of moisture removed. They are then smoothed out on the stoning jack, when they are ready for the splitting machine. After splitting into as many splits as the thickness of the side allows, or as the desired weight of the leather which is being made, requires, the splits are trimmed by hand and may be taken to the shaving machine for smoothing and

to remove any humps. The splits are then retanned in a revolving drum, or wheel, with extract liquor. Some of the liquors which are in common use for this purpose are quebracho, cutch, gambier, and palmetto extracts. The wheel treatment requires from ½ to 2 hours. From the retanning wheel, the splits are carefully spread out and piled, the piles when completed being covered with canvas and allowed to stand from 24 to 48 hours, so that the liquor received in the wheel may complete its combination with the hide substance.

After retanning, the leather is *cleared* by being run in a revolving drum, first with water, then with a solution of borax, then water, then a weak solution of sulphuric acid, and finally with another water, each solution being removed before the next solution is added. After clearing, the splits are run in a wheel with a sumac liquor, and occasionally some of the oiling is done in this wheel. The leather is then sorted and different grades assigned for different colors and for different purposes. The grain splits showing no hide imperfections are finished in the natural color for the best grades of leather. When the grading is finished, each lot of leather is dyed the assigned color, the dyeing being done either in a vat with a paddle wheel or in a tight drum. Leather to be dyed on one side only is, of course, colored by hand or by the blackening machine.

11. After dyeing, the leather is hung over sticks to harden, or it may be worked out and the excess of moisture removed by the machine. When properly tempered, the leather is worked and oiled by hand on a table. The table is swabbed with oil, the split being laid on it grain side up. After working out the excess of water and breaking or softening the leather, the grain is lightly swabbed with oil and then tacked on the drying frames and dried. When dry, it is removed from the frames, moistened to the proper degree, and a light oiling or a seasoning applied. The leather is then thrown over wooden horses and allowed to temper, and may receive subsequent treatments with either seasonings alone or seasonings containing dyes, to bring the color to the desired

shade. After the seasoning treatment is completed, and when properly dried, the leather is surfaced on a surfacing machine, and may be finished with a glassing machine. It is then *boarded* by hand to break the leather, complete and make permanent its limp character, and give it a particular style of grain, if desired. This is done by light pressure on the cork-faced boarding tool strapped to the arm of the operator, the leather being doubled and the tool moving over the fold of the leather. Different degrees of dampness and different ways of operating the board result in different grain surfaces.

12. If the leather is to be embossed in imitation of any grain desired, the embossing is done before or after the machine surfacing. The leather should be properly dampened, and, after embossing, it is dried and boarded. If the leather is to be blacked, the blacking is applied after seasoning. Three coats of any amyl acetate black are given, one coat being allowed to dry before the next is applied.

It may be finished smooth or may be dampened and embossed in imitation of seal, or any desired grain, after which it may be run through a splitting machine to produce the particularly light leathers used for card cases, for covering boxes, or for decorative purposes, etc.

The grain split from the hide is made up into the better grades of bag, strap, and fancy leather, while the flesh splits are generally used for cheap bag and strap leather, rough gloves, and innersoling. The flesh splits are frequently dyed, finished, and embossed, and sold for grain leather.

13. For certain kinds of strap leathers, also harness and belting leathers, where strength is the principal requisite and a slight darkening of the color is not objectionable, it is customary to fill the leather with a large amount of oil, the amount of oil and grease introduced often running as high as 45 per cent. of the weight of the finished leather. The material and processes employed are as follows:

14. Stuffing Materials.—The treatment of leather in such a manner that it will contain an amount of grease or oil

such as its future use may require is called *stuffing*. Stuffing is done both by hand and by machine, largely by the latter method. The former is used only on certain classes of leather.

For stuffing leather, the oil par excellence is cod-liver oil. It has been in use since the early days of the industry, and as yet no other oil has been found that can satisfactorily displace it. Cod-liver oil has a good body and remains in practically the same state in which it entered, thus giving to the leather a permanent mellow feeling.

This oil is expensive, and therefore substitutions are common. Seal, menhaden, and mineral oils are commonly used for this purpose.

It is almost impossible, with any marked degree of certainty, to detect the fish oil when mixed with cod-liver oil. Fish oils have more gum than the genuine cod-liver oil; but cod-liver oil and menhaden oil have the same color and gravity, and their range of odor and taste is about the same.

Menhaden oil, when cold pressed to remove the foots, is a good substitute for the average grade of cod-liver oil.

Stearin, tallow, beeswax, Japan wax, and paraffin wax are all used for stuffing certain kinds of leather.

Heavy refined mineral oils are largely used for mixing with cod and fish oils for stuffing heavy leather.

Neatsfoot oil is used with satisfaction if a good cold-tested oil is secured; otherwise, a cold temperature will congeal the oil and thus turn the skin white.

Sod oil is largely used for stuffing. It is pressed out from skins, and is ready for use after boiling and undergoing clarifying treatment.

Degras is the oil obtained from wool during its cleansing process. French degras is the surplus oil obtained in the manufacture of chamois leather. It is frequently adulterated and is put on the market in all grades.

Glycerine is used by some tanners instead of degras. It imparts to the leather a high degree of softness, but it should not be used alone, as it possesses a corrosive action and, being

soluble in water, is easily removed from the leather by dampness.

Porpoise oil is much valued for stuffing.

Wool fat, obtained from the solvents used after extracting wool, is sometimes used as a substitute for degras.

Olive oil is used in leather dressing, particularly in alum tannage.

Castor oil is largely used, especially in its sulphonated form, known as Turkey-red oil, which is made by treating cooled castor oil with successive small portions of strong sulphuric acid. After standing, the oil is separated with salt solution and carefully neutralized.

Sperm oil is occasionally used in finishing leather, and it is sometimes used in fat liquors.

The yolks of eggs are used in stuffing high-grade glove leather, as it contains about 30 per cent. of an oil known as egg oil.

15. Hand Stuffing.—In hand stuffing, the leather must be in a damp condition and the daubing mixture consisting usually of cod-liver oil and tallow, is applied to the flesh. By means of a heavy slicker, the hides are worked on the table and then placed in piles in a warm room. The operation is repeated several times or until the necessary amount of oil has been introduced. As practiced, the operation of hand stuffing consists of rolling the sides into bundles, with the grain side in, and softening by heating; then the warm oil and tallow is applied with a brush to the flesh side.

16. Drum Stuffing.—In the drum-stuffing method, the stuffing is effected by placing the hides and stuffing material in a revolving drum *a*, Fig. 5. The hides are dampened thoroughly on both sides and allowed to lie in a pile, which is then covered with damp cloths. The drum is heated by steam or hot air for some time before receiving the stock. The heat is turned off and the hides placed in the drum, which is then run for some time with the door loosely closed. This operation loosens up the goods and regulates the temperature. The stuffing material is then run in hot, but not hot enough

to scald the hides. The tight door is put on the drum and the stock wheeled for from ½ to 1 hour. The drum is stopped and the door opened, and the drum is then slowly revolved for a few minutes. The hides are finally taken out, smoothed, and laid in piles.

They are generally stoned as soon as possible on marble or plate-glass tables (it is best to stone on the grain side first) and then hung up until nearly dry. The operation is repeated on the flesh side, removing all marks of the stone, after which the sides are again hung up until quite dry. There

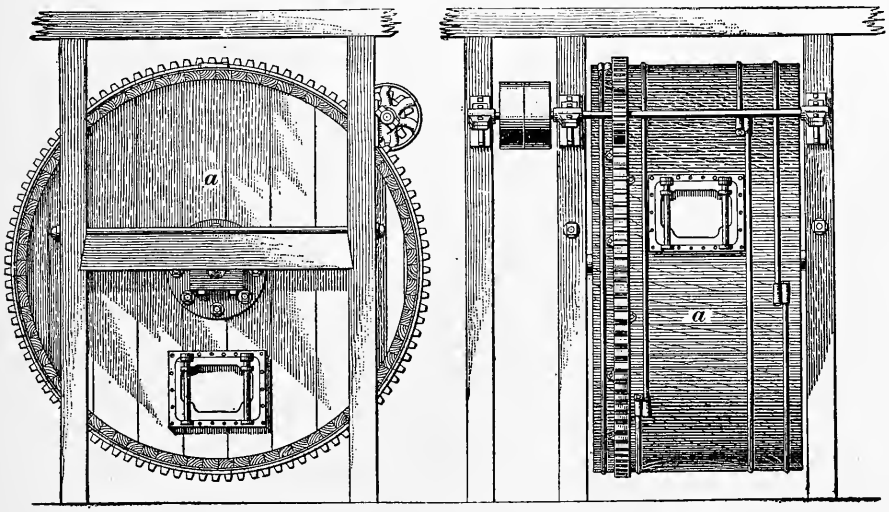


FIG. 5

are several patented forms of stuffing drums in which the heating is effected by means of coils containing steam or hot air. The coils keep up the temperature of the drum while the stuffing is going on and do away with the water of condensation.

A *hot-air stuffing mill* is shown in Fig. 6. The air for the drum *a* is heated by steam coils in the heater *b*, from which the heated air is forced into the stuffing drum by means of a small fan blower, as indicated.

17. Fat-Liquoring.—For certain kinds of vegetable-tanned leather, especially light leather, the oil and greases are replaced by so-called fat liquors. These fat liquors are simply emulsions of different oils, fats, and soaps, the character of

which depends on the kind of leather and its future use. Egg yolk is an example of a natural fat liquor. For some leathers, a fat liquor made up of water, olive-oil soap, olive oil, degras, and Turkey-red oil, is used. Some tanners use a mixture of water, neatsfoot oil, glycerine, and castor-oil soap, and there are many other combinations of soaps and

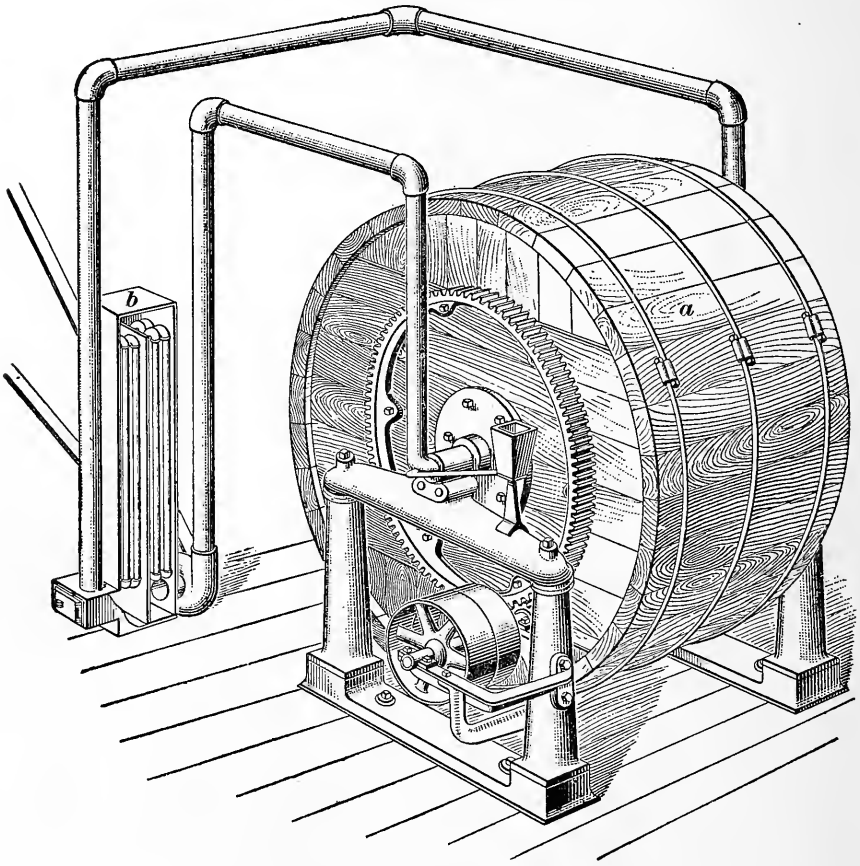


FIG. 6

oils used for fat liquors. The preparation and use of fat liquors is a part of the finishing process that has a marked influence on the softness and durability of the leather produced. Fat liquoring is done in a regular stuffing drum and the fat liquor added continuously during the revolution of the drum.

18. Buffing, or Whitening.—The buffing, or whitening, required in the manufacture of some classes of leather

is done either by hand or by a *buffing,* or *whitening, machine.* If done by hand, the leather is laid either on a table or on an inclined beam, similar to the beam used in the beam house, and buffed by scraping with a broad buffing tool.

19. Whitening Machine.—Whitening by machinery is effected by a machine, shown in Fig. 7, consisting of a rapidly

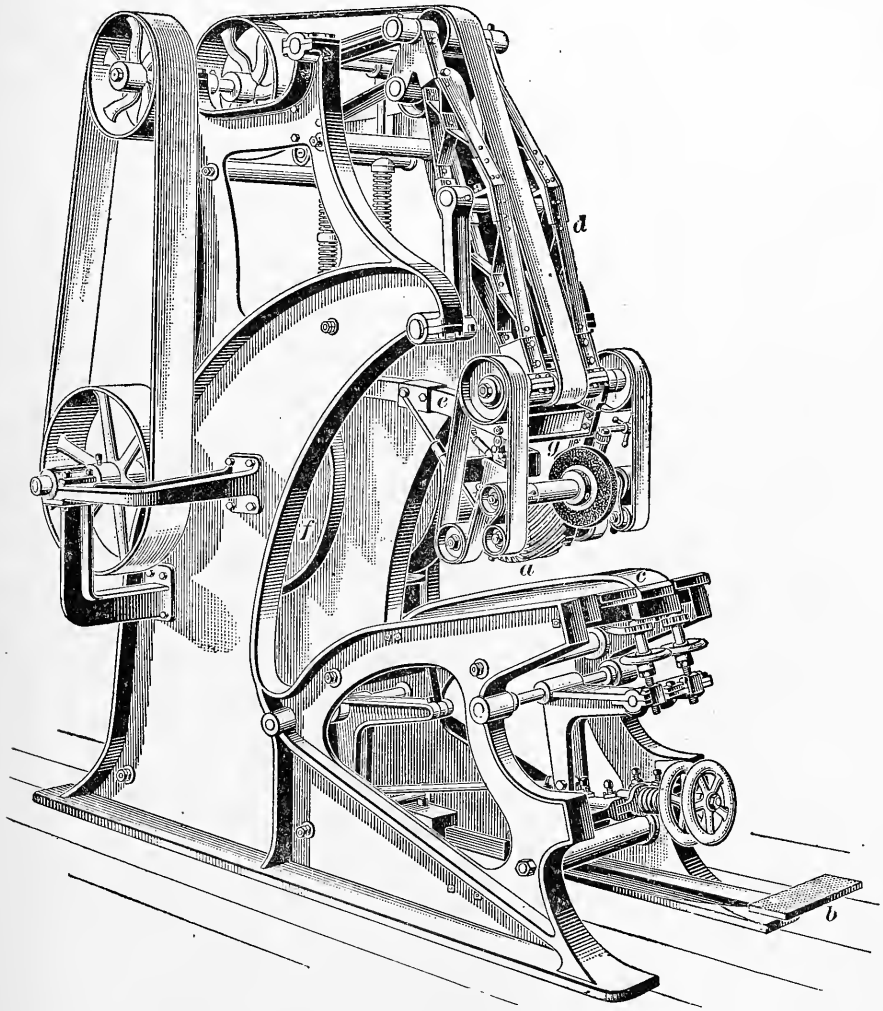


FIG. 7

revolving cylinder on the end of an arm having a pendulum motion. The face of the cylinder is covered with parallel knives, or spines, running transversely. The leather is laid on a bedplate under the moving arm, and the arm, with the

cylinder, is lowered by means of a foot-treadle until it comes in contact with the leather. The pressure of the tool on the leather is regulated by the operator, who keeps the leather moving so that one section of the surface does not receive more of the abrasive action of the cylinder than another.

The whitening machine illustrated is made of iron. The rotary cylinder, or whitening tool, *a* is driven by belts at either side and running on a small countershaft fixed in boxes at the end of the supporting double truss, or pendulum, *d*. The belt running the countershaft passes between the parts of the truss and over a pulley at its upper end, and thence to the main driving belt. The pitman *e* is connected with the balance wheel *f*, and from it receives a backward and forward motion. The foot-treadle *b* is for regulating the distance between the cylinder and bedplate *c*, and, accordingly, the pressure on the leather. The bedplate is of polished brass, is slightly wider than the cylinder, and is inclined. A revolving emery wheel *g* travels constantly from one edge of the revolving cylinder to the other, keeping sharp the faces of the knives, or spines of the cylinder.

SIDE LEATHERS

20. Splits.—Leathers made from split cow and steer hides tanned by a vegetable-tanning process are used to a large extent in various grades of shoes. The same conditions as to varieties exist with this class of leather as with other classes. The hides are usually split out of the lime, the grain going into mineral tannage while the split is vegetable-tanned. This flesh-split is used largely for cheap shoes as brogan leathers, are stuffed in the drum and then grained or waxed as desired.

The splits from side leathers are also sometimes given a pyroxylin finish and are known as *dope splits*.

When the splits are to be finished for cheap shoe leather the stock after stuffing is cleaned smooth by working on the whitening machine after which it is ready for the color.

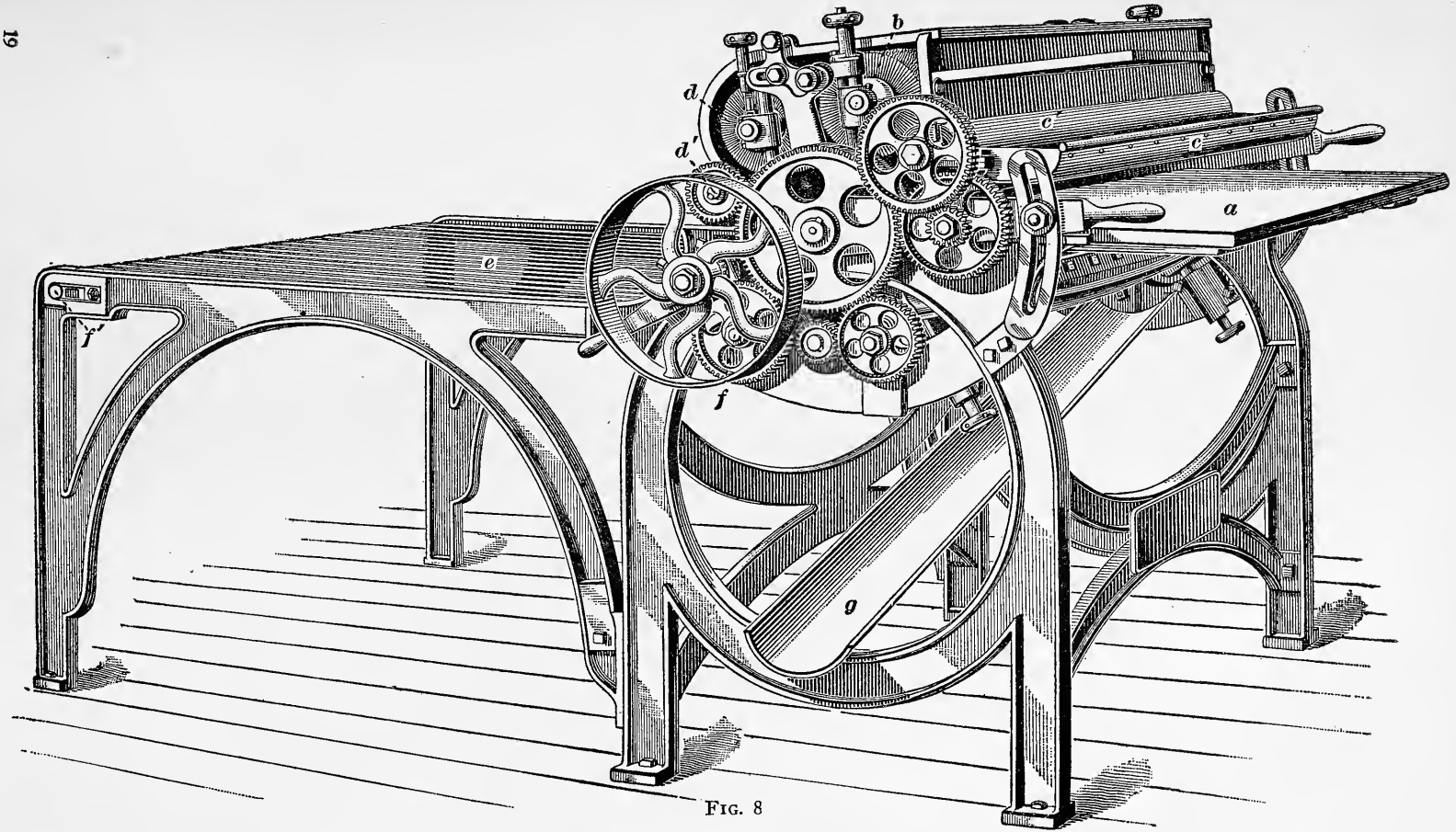


FIG. 8

21. Blackening.—After whitening, or buffing, the leather is ready for blackening. For the heavy grades of upper leather, this operation is preferably done by hand. The liquid blacking or other dressing to be applied to the surface of the leather is spread evenly over the hide by means of oval brushes made of fine bristles. The excess of blacking is removed by other brushes, care being taken that no blacking reaches the under side of the leather.

22. Blackening Machine.—A popular machine for blackening leather is the *Batchelder,* shown in Fig. 8, or modifications of it. In this machine, the leather is spread on the table *a* and fed into the machine. The edge of the leather is engaged between the surfaces of two rolls and then passed over a third roll, which forms a supporting bed for the skin, while the brush *b* applies the blacking. The blacking or other dressing is in the receptacle *c,* and the fluted roll *c'* running at the edge of the blacking receptacle supplies the brush with the coloring matter. The brush *d* seems to work the blacking into the leather and also to remove any excess. After passing under the second brush over the supporting roll *d'*, the leather is delivered to a moving bed *e,* formed by endless tapes extended around rollers *f* and *f'* and driven by gears.

As the hide does not always cover the roll supporting it under the blacking brush, some blacking reaches the roll. This roll must be kept clean, otherwise the under surface of a wide portion of hide will become soiled with the blacking. A wiper or cleaner of some flexible material, held by an adjustable bar against the lower surface of the roll, effects the cleaning. The material wiped or scraped from the roll drops into the trough *g* and passes to a bucket provided for that purpose.

The rows of bristles on the brush are so arranged that alternate rows incline in different directions, those of one row inclining toward one end of the cylinder and those of the next alternate row toward the opposite end. In this way, the ends of the bristles, besides traveling over the leather in

the direction of rotation of the brush roller, also, when in contact with the leather, spring in opposite directions longitudinally and thus work the blacking backwards and forwards, as well as in the direction of the movement of the roller, effectually blackening the leather and preventing streaking.

If the leather is to be dyed, the dyeing may take place immediately before or after the stuffing, and in some processes the dye solution is added in the stuffing drum.

SHOE, GLOVE, AND FANCY LEATHER

23. In the manufacture of the shoe leather, as well as glove and fancy leather, there are certain mechanical processes which must be followed in order to obtain the desired results. As these operations are common to all three of the classes mentioned, it will be well to give a description of them here.

24. Working Out Skins.—For *working out* the skins in different stages of some processes in light-leather tanning, the serial table machine shown in Fig. 9 is largely used. Machines of this type are used also for unhairing light skins, but they are used mostly for working out and for setting out the skins. Through treatment by this type of machine, most of the water is removed from the skin, the grain is made fine and silky, and the skin is well stretched and left in good condition for oiling and drying.

The rubber-bolstered tables a, a_1, and a_2 are attached to the endless chains b, and are slowly carried between the double rolls shown at c and c_1. The rolls are spirally bladed, and the skins, being carried between the rapidly revolving rolls, are subjected to their action both at c and at c_1. As the machine is constantly in motion, the skin is thrown over table a with its backbone lying along the upper edge. The table is then carried up and passes between the rolls at c_1. When the table is clear of these rolls, the bolsters and skin are automatically moved so that the backbone, which was not worked between the first pair of rolls, is brought in position to be worked by the second pair of rolls at c. In addition

to setting out the backbone, the upper rolls perform a second working operation on the other parts of the skin. The bolster

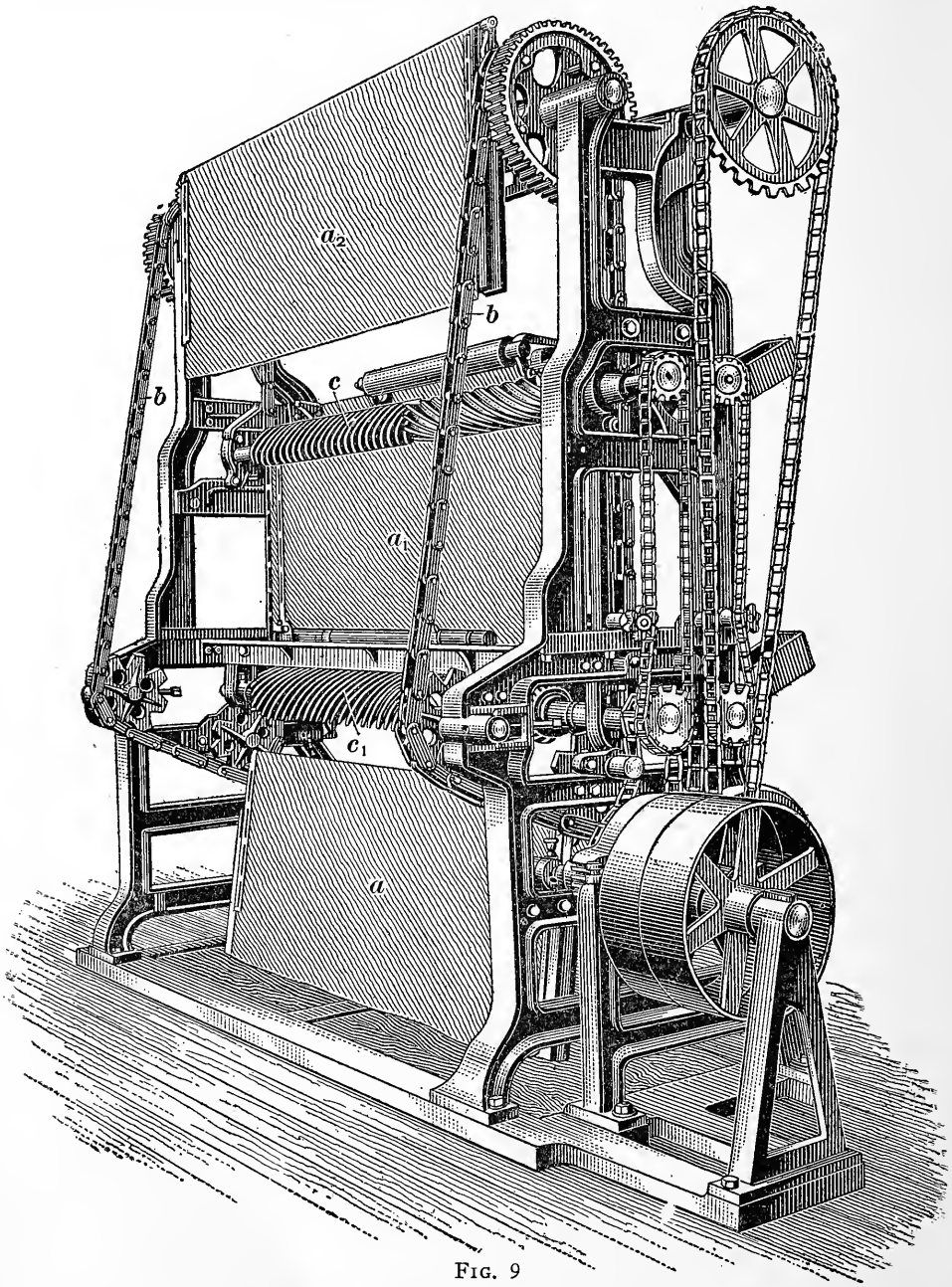


FIG. 9

is now moved back to its original position and the table descends. The skin is then removed, another skin thrown on the table, and the operation repeated indefinitely.

The wet skins are put on the tables at one side of the machine and the worked skins are removed at the other side, so that each operator has the one duty to perform. Recently patented inventions provide for the automatic removal of the worked skin, so that only one operator is needed for each machine.

25. Shaving.—After tanning the stock, it is piled on horses for a short time to drain free from excess moisture and is sometimes pressed and then milled for half an hour

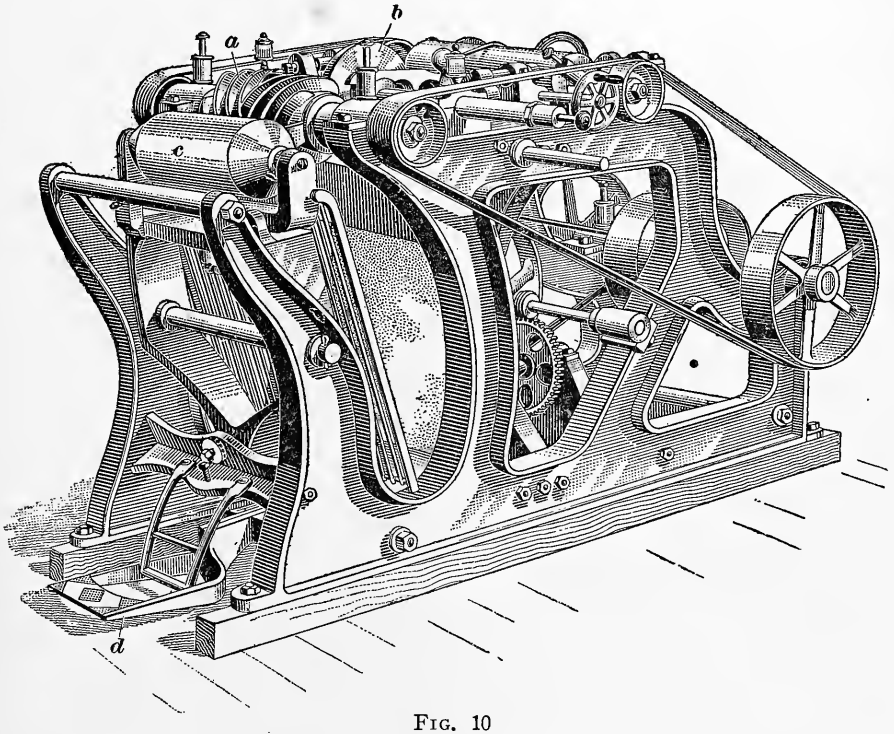


FIG. 10

with flour or talc. The skin or sides are then shaved on the flesh to make them smooth and to remove any lumps or irregularities in thickness. This work was formerly done by hand, but is now almost universally accomplished on the shaving machine shown in Fig. 10. The machine consists of a cylinder *a*, having spiral blades set in its surface. The blades are ground by the emery wheel *b*, which moves from one end of the shaving cylinder to the other while constantly revolving. The machine being set in motion by a belt shifter, the

skin is thrown over the roll *c*, and pressure on the foot-treadle *d* throws the roll *c* forwards, bringing the skin in contact with the rapidly revolving shaving roll *a*. The skin is moved by the operator so that, by varying the pressure of the skin against the shaving roll, any desired amount of shaving may be done on any portion of the skin. The spines of the shaving roll are constantly being sharpened by the action of the grinding wheel *b*.

26. Staking.—After light leathers are dried, it is necessary to soften and loosen the fibers so that the leather becomes soft and pliable. This operation is called *staking*, and was formerly done entirely by hand, the workmen pulling and

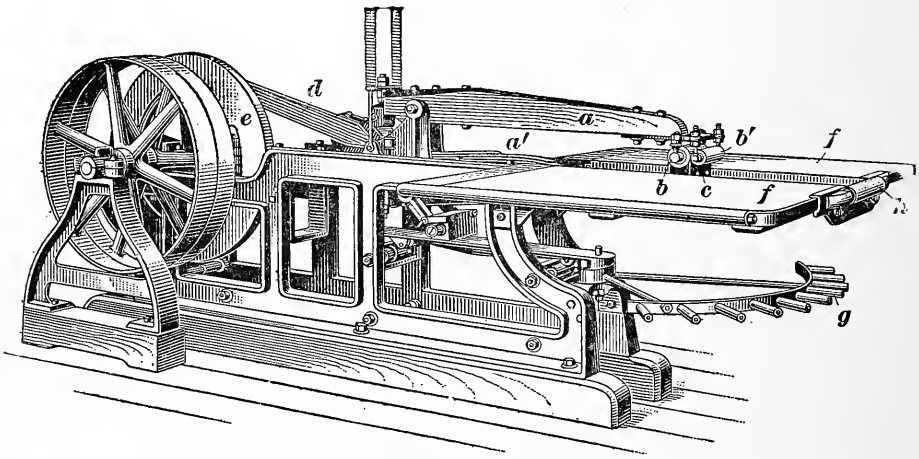


FIG. 11

stretching the skins across a stake, or perch, and using hands and knees in the laborious task. In Fig. 11 is shown a representative type of staking machine by which the greater part of the staking is done, machine staking having largely superseded the hand method.

The machine consists of a pair of tongs *a* and *a'*, the upper arm *a* having at its extremity two felt-covered rolls *b* and *b'*, between which enters the staking blade *c*, attached to the extremity of the lower arm *a'*. By means of a crank and a connecting-rod *d* the tongs are attached to the crank-wheel *e*, causing the tongs to move backwards and forwards in the

divided table *f*. A cam actuated by the connecting-rod opens the jaws of the tongs on the forward stroke, and they are closed by springs on the backward stroke. The knee pressure regulator *g* adjusts the pressure of the staking tools on the jaws, so that any desired pull on the leather is at the control of the operator.

In staking, one end of the skin is laid against the roll *h* and held by the pressure of the operator's body, the sides of the skin being firmly grasped by the hands and inserted between the staking jaws of the tongs. The skin is moved about so that all parts are subjected to the action of the staking tools, the pressure or pull necessary for any particular skin, or for any particular part of a skin, being regulated by the lateral movement of the operator's knee against the pressure regulator *g*.

27. Seasonings.—The finishing solutions applied to the surface of light leathers are known as *seasonings*. In addition to giving the finished appearance required by the market, they serve as a basis for a glaze and make the grain surface more elastic. Their composition varies with the class of leather being finished, and many materials and combinations are used in making the seasoning. For colored leather, a mixture of egg albumen, flax seed liquor, and gum tragacanth is frequently used, and in addition the solution may contain some of the dye originally used on the leather. Blood, casein, and milk are also used in seasonings for this class of leather. Seasonings for black leathers, in addition to the materials mentioned, often contain dichromate of soda, logwood liquor, isinglass, Irish moss, etc. Skivers and thin skins are often treated to seasonings of gums and resins dissolved in alcohol.

The composition of seasonings is really a matter of experience, to be determined by the currier who has watched the effects produced by different ingredients and different proportions of the same ingredients. Each currier has his own formulas for different effects, and probably no two agree on the question of seasonings, except that the seasoning should be applied in very light coats and should be well rubbed into the leather.

28. Surfacing.—After being properly prepared, the leather is submitted to a surfacing process. The surfacing operation is sometimes performed by hand, but by far the greater part of the leather finished in the United States is *glazed, rolled,* or *pebbled* by machinery. The operation of the surfacing machine shown in Fig. 12 is similar to that of the rolling machine used in the manufacture of sole leather, but it is lighter in construction. The roller *a* runs in boxes on the end of a beam *b* connected directly to a wheel *c* on the drive shaft, which imparts a direct backward and forward motion to the beam. The end of the beam is supported by a pivoted truss *d,* which also serves as a guide, so that the

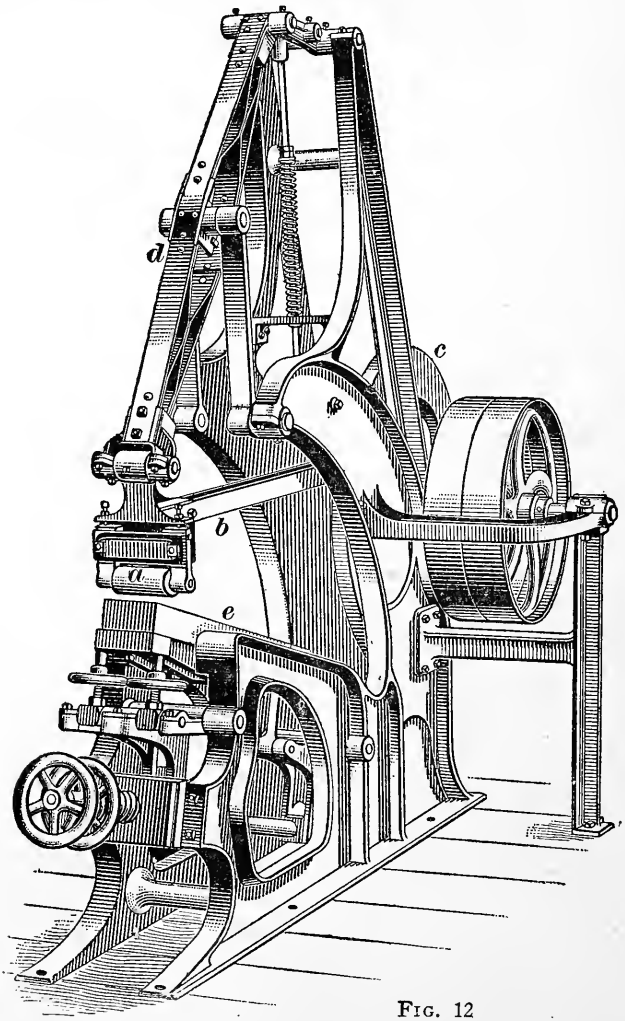


FIG. 12

roller runs in a line parallel to the face of the bedplate *e*. The bed on which the leather is laid is inclined and its face is straight. On all machines for finishing the surface of leather, every precaution is taken to guard against oil or grease coming in contact with the leather. A single grease spot will greatly depreciate the market value of a skin. The rolls are generally self-oiling and the boxes are especially devised to guard against oil leakage.

29. Glazing.—For *glazing,* a smooth roller is used, the leather being laid on the bed and moved around under the moving roll, so that every part of the surface receives its polishing action. The heat essential to a good polish, or glaze, is supplied by friction of the roll, and the operator must be careful not to maintain too great a pressure on the leather, or the heat generated will burn the leather. The bed is controlled by screws in front of the machine. One screw raises or lowers both ends of the bed at the same time, another screw regulates the pressure for both ends, and the other screws adjust the bed to any desired position.

For the final finishing, a machine in which a piece of smooth, rounded glass is substituted for the roll *a,* Fig. 12, gives the leather a high luster.

An electrically heated roll that has lately appeared on the market has become quite popular. The roller is heated to the temperature necessary for a good polish, so that pressure need not be resorted to in order to produce heat.

30. Pebbling.—For *pebbling, dicing, graining,* or for giving the leather any desired surface, different rolls are substituted for the smooth roll used for rolling and glazing. These rolls have their surfaces cut in the desired figure, and by the action of the machine the design is imparted to the surface of the leather.

VEGETABLE-TANNED CALFSKINS

31. Black and colored shoe leathers made from calfskins by a vegetable tannage are manufactured in the following manner: The skins are soaked, fleshed, and then limed in a

mixture of lime and red arsenic, or one consisting of lime and sodium sulphide. After removing the hair, the skins are bated in oropon, or by means of bran or organic acids. After washing off the bate, the tanning of the skins begins. Various liquors are used in different tanneries, and they are generally combinations of two or more tanning agents. Among the materials used are hemlock, oak, quebracho, palmetto, and gambier. The tanning is done either by hanging the skins on rockers in the liquors or by the use of a paddle wheel. The same general rules for vegetable tanning of heavy leather, as to gradual increasing strengths of liquors, are observed, but the tanning is conducted with weaker liquors and in such a manner as to produce a tough, mellow leather.

32. After the tanning, the heavier skins may be split and the splits retanned in a paddle wheel with either gambier or quebracho liquor. The lighter skins are immediately drained, pressed, shaved, and they are then ready for stuffing. The stuffing is sometimes done with oils, but more often a fat liquor made of soap and degras, or soap, oil, and degras, is used. After the stuffing, the skins are set out by hand or machine, and then dried. The finishing is done by dampening the dried skins and then running them in a wheel with sumac liquor, so as to prepare them for the coloring. If a natural or a lighter color is desired, the skins are sometimes cleared by running in the mill first with borax water, following this with an acid solution, and finally washing with pure water, after which they are set out by hand or by machine. For coloring, the skins are first drummed with a fustic-extract solution, and after draining off the extract liquor, the dye solution is added to the drum and the drumming continued until the coloring is complete. To set the color, the skins are then rinsed in a weak solution of alum or other chemical, depending on the character of the dye used, and they are then set out. When dry, they are slightly dampened in sawdust and made soft and pliable by staking on the machine or by hand. Then they receive a coat of paste made up of flour and tallow, and when this is dry the skins are lightly glazed.

The seasoning is applied and the skins are glazed and hung to dry. After this, another coat of seasoning is applied, followed by a glazing. The stock then receives any desired graining, and the leather is ready for market.

33. If black leather with a purple or yellow flesh side is desired, the flesh dye is put in the drum, and the grain dye is applied by machine, on tables by hand, or by folding the flesh side together and immersing the folded skin in the dye. On vegetable-tanned leather, the black coloring is generally effected by a solution of logwood and soda, followed by a striker solution made of a soluble iron salt. After the grain is dyed, it is washed off with warm water, set out, and a light coat of oil given. The leather is then hung up to dry.

The numerous brands and varieties of vegetable calf leather now on the market are produced by varying the finishing treatment of tanned calfskins as regards the amount and character of stuffing, the character of pastes and seasonings, and the luster and style of grain given the leather. The general treatment for all these leathers is as described. However, no two factories tan or finish leather by exactly the same methods.

34. Wax Calf.—The class of leather known as *wax calf* has lost its popularity, and hence is not so extensively made as formerly. This leather is made from calfskins by a vegetable tannage, and is very heavily stuffed with oil, grease, and wax. The flesh side is shaved and carefully smoothed by hand, and grease black is applied to this side, the grain side being left uncolored except for the color of the tanning agent used. The finishing is done on the flesh side, and the entire skin receives a final oil soaking and is then rubbed to give it a final market finish. The grain side being next the foot of the wearer of the shoe, the flesh side of the leather is exposed to wear, and scratches or scuffs received are easily concealed by an application of shoe polish. Because of the stuffing used in this class of leather, the clothing is easily soiled on coming in contact with the shoe, and this has helped to decrease the popularity of this wear-resisting leather.

During the World War the leather used for army shoes was finished on the flesh in somewhat the same manner as described. No coloring material, however, was used and so the shoes had the natural color of the tanned product. Such leather was used only for heavy service, and a leather finished on the grain was furnished for shoes intended for ordinary street wear.

VEGETABLE-TANNED SHEEPSKINS

35. Sheepskins come to the tanner salted, either as they are taken from the animal or with the wool removed, the skin having been pickled in sulphuric acid and salt solution. Large quantities of skins are split and the pickled splits are shipped to the tanners in casks.

Sheepskins are made into a variety of leathers and are tanned by processes similar to those used for tanning other skins. Considerable sheep leather finds its way into the uppers of shoes supposed to have glazed-kid uppers, and sheep leather is largely substituted for kid and goat leather for other uses. The whole skins are tanned by the oiling process, the chrome process, the vegetable process, or by a combination of mineral and vegetable tannages, the leather being used for shoes, coats, aprons, suspenders, bookbindings, linings, etc. When the sheepskins are split, the grain split or skiver is generally tanned by vegetable processes for linings, sweatbands for hats, bookbindings, gloves, etc. The flesh splits, or fleshers, are used for making chamois leather.

36. Preparation of the Skins.—The wool is removed from the sheepskin by thoroughly washing the skin first and then lightly painting the flesh side with a mixture of lime and sulphide of sodium. The skin is then folded along the spine line, flesh side in, and piled in low piles to stand until the wool slips easily. After the wool is pulled, the skins are washed in clean water and put into the limes. After liming, the skins are fleshed, washed, and bated, or drenched, in organic acids or bran. They are then washed and placed in a pickling solution made of salt and sulphuric acid. When the

pickling is complete, the skins are removed, allowed to drain, or are pressed, and are then ready for shipment to the tanner. If skivers, or splits, are to be made, the skins are split by a belt-knife machine on coming from the limes. The pickling of the skins preserves them and also taws the skins into a kind of white leather.

Sheepskins are very greasy, and, to get the best tanning results, the grease must be removed. Sometimes, the skins are pressed during the beam-house operations, thus removing much of the grease before pickling. Hydraulic presses are used and sawdust is sprinkled over the skins to keep them from slipping. The grease is removed by the use of wringers; naphtha is also used to dissolve out the undesirable grease.

When pickled skins, or splits, are received at the tannery, they are first run in a wheel with whiting and salt, borax, or borax and whiting, in order to remove any acid. They are then washed and given a drenching made of bran and salt, after which they are ready for the chosen method of tanning.

37. Tanning of Sheepskins for Rugs, Fur Coats, Etc.—Many sheepskins are tanned without removing the wool, for rugs, mittens, linings for coats, etc. For such purposes, the skins are well soaked in water and fleshed. The wool is washed thoroughly with a solution of soap and soda and rinsed in clean, warm water. The tanning, or tawing, is done by means of mixtures of alum, salt, and saltpeter. The skins may be allowed to soak in the liquor, or the latter is mixed with bran and the paste spread on the flesh side of the skin, which is then folded and allowed to remain in contact with the paste until the tanning is complete. If white skins are not desired, the tanning may be done in a liquor made of hemlock, gambier, or sumac, which should also contain salt and alum. The skins are frequently handled in the tanning solution, and, when tanned, are washed, drained, oiled, dyed, and dried. The alum-tanned skins are frequently worked and stretched while drying, so that when dry they will be soft and pliable.

38. If the skins are to be white, the wool is scoured with a strong soap solution, and the skins are hung in tight rooms and subjected to the fumes of burning sulphur to bleach the wool. Sodium hypochlorite, permanganate of potash, and hydrogen peroxide are also used for bleaching.

In dyeing the wool on either alum- or bark-tanned skins, the wool is first thoroughly washed and rinsed, and the skin stretched on a board. The board is lowered into the dye bath so that the wool is dyed, and the wool is then rinsed, carefully dried, and combed. The wool on bark-tanned skins takes a natural dye from the tanning materials used, and this is frequently the only dyeing it receives.

HOGSKINS

39. Hogskin leather is extensively used for bags, saddles, footballs, etc. It is readily tanned by any of the vegetable-tanning materials. After the beam-house treatment, the skins are tanned in various combinations of oak, hemlock, quebracho, or gambier liquors, in paddle wheels, rockers, or drums. From 6 to 10 days are required to tan the skins thoroughly, and the leather is then cleared, or bleached, by running in a solution of borax or soda, followed by an acid solution, and finally with clear water. It is then given a sumac wheeling, set out by hand, a light coat of oil is given, and then it is dried. After drying, the skins are dampened and shaved, the heavy skins being split. They are then fat-liquored and slowly dried, and allowed to temper for a few days. The leather is then dampened and dyed in a wheel, set out, oiled, and dried. When dry, it is packed in sawdust and staked, or gone over with boarding tool, and after receiving a light seasoning, it is lightly glazed on the machine, when it is ready for shipment.

TAWING

40. For making certain classes of white leather, such as leather for belt lacings, and glove leather, certain agents that are quite different from any previously mentioned, are used. Processes requiring the use of mineral tanning agents were

originally known as *tawing,* but the term has been enlarged and now includes *chrome tanning.*

In tawing, yolks of eggs, flour, alum, and salt are used. The hides treated with these agents become tough and pliable, can be stuffed, and will not decompose.

41. Kid-Glove Leather.—As an illustration of tawing leather, the process for turning lambskins and kidskins into glove leather may be described briefly. The skins are thoroughly soaked in cold water for a couple of days and, when soft, are put into a revolving drum in which are fixed wooden pins that thoroughly shift the skins. Water run through the drum while it revolves thoroughly saturates the skins and removes the dirt. After washing, they are given a long liming in pits, and the excess of lime afterwards removed by thorough washing. They are then unhaired and fleshed. After further washing in the revolving drum, the skins are bated or puered in oropon. After being well washed, they are put into the tanning drum with the tanning liquor. This is generally composed of a mixture of sulphate of aluminum, sodium bicarbonate, salt, flour, egg yolk, and water.

After running the drum from 12 to 15 hours, the skins are taken out and hung up to dry and left in the so-called crust or dried condition for several weeks. This treatment results in a combination of the skin with the aluminum sulphate and the leather becomes thoroughly tanned. On removal of the skins from the crust, they are brought to a sammied condition by dipping in warm water and placing in piles. When in the proper soft condition they are knee-staked by drawing them over a round blunt knife. This knee-staking pulls out the skin to its full dimensions, renders it soft and pliable, and at the same time removes any adhering material left by the tawing treatment.

The well-staked skins are buffed to smooth the flesh side, given another treatment with egg yolk, and allowed to dry. When dry they may be colored or finished in white as desired.

42. Lace Leather.—Another example of tawing is in the manufacture of leather for lacing and whips. The hides are

soaked, depilated in a mixture of lime and sodium sulphide, and, after fleshing and unhairing, are washed and bated. They are then run in a drum with a mixture of alum, salt, sal soda, and bran. After this treatment, they are hung in the loft and dried, and when dry, are wet down and a mixture of neatsfoot oil, linseed oil, and tallow applied. The hides are then dried and, when dry, are slightly dampened and worked by hand or on the machine until they are soft and pliable. After the application of another coat of oil, they are ready for the market.

43. Alum Combination.—Alum-tanned leather, although it is tough, has the disadvantage of being thin and, when wet, becomes hard. To overcome these drawbacks, it is common practice with some grades of leather to retan the skins in some form of vegetable tanning material. This retanning is usually accomplished by running the alum-tanned stock in paddles which contain a solution of gambier. By this procedure it is not necessary to allow the stock to remain in the crust, and the leather may be fat-liquored, colored, and finished in a manner similar to that described for straight vegetable tannage.

44. Pyrophosphate Tannage.—A form of alum tannage which has many points in its favor, consists in adding sodium pyrophosphate to the salt and sulphate of aluminum mixture. The insoluble aluminum pyrophosphate is readily absorbed by the stock and the necessity for crusting is obviated. The skin or sides treated by this process may be dried, sammied, fat-liquored, and finished, or they may be retanned and handled like vegetable tanned leather.

45. Castor and Mocha Leather.—A form of alum-tanned leather which is used very largely in glove manufacture, consists in giving the skins a very long liming, sometimes lasting up to two months. By this long-lime treatment the grain of the skin is loosened and readily removed by means of a blunt knife or stick. The operation of removing the grain is known as *frizing*. The frized skins are then washed, bated, and drenched, and an alum tannage applied. The

tanned leather, after staking and buffing, is finished with a combination of clay and color. This excessive liming, together with the removal of the grain, produces the soft, pliable appearance of this class of leather.

OIL TANNAGE

46. Chamois Leather.—The so-called chamois leather is made from the *fleshers,* or flesh splits, of sheepskins. The splits are thoroughly washed and may be bran-drenched, after which they are pressed to remove the excess of water. They are then thrown into a heavy machine similar to the hide mill used in sole-leather tanneries and worked with cod oil or a good grade of fish oil. Several additions of oil are made while the skins are being worked in the beaters, and the operation of beating consumes much time. When the operation is ended, the skins are removed from the mills, or beaters, and arranged in piles or hung in closed rooms. This causes the skins to heat, completing the oxidation of the oil that has been beaten into the skins. After this treatment, the skins are placed in a hydraulic press and the excess of oil and grease pressed out. The product of this pressing is known as degras and is used in the finishing of many kinds of leather. After this pressing, the skins are washed in a solution of sal soda, which saponifies any remaining oil and grease. The soap thus formed is treated with weak sulphuric acid, which releases the fatty acids. This oil is the sod oil of the currier. After the removal of the oil, the skins are washed, dried, staked, and made smooth and pliable by working, when they are ready for market.

47. Oil-Tanned Sheepskins.—Another example of an oil-tannage production is the old Napa leather, which is really a soap-and-oil-tannage product and not the result of a pure oil tannage, as is chamois leather. The wool is removed from the skins by painting on the flesh side with a mixture of lime and sulphide of sodium, and the skins are thoroughly washed

and then pressed in a hydraulic press to remove the grease. The skins are then run into a revolving drum containing a solution of salt and sal soda, or potash. From this solution, they are removed and pressed, or wrung, and run into a drum with a solution containing soap and neatsfoot oil. When this solution has penetrated the skins, they are removed and pressed. The heavier skins are returned to be retanned, while the lighter skins are colored and dried. When dry, they are moistened and staked and then stretched and tacked on frames and thoroughly dried. When dry, they are buffed, or shaved, and finished to the desired dull or glazed finish.

This leather is soft and possesses considerable strength, being largely used for linings, bookbindings, and as trimming for fancy braces and suspenders.

48. Buckskins.—In the manufacture of buckskin leather, deer skins are the raw material used. The skins are given a long lime treatment, usually extending over forty days. The grain, having become loosened, is removed by frizing and after bating and drenching, they are given an oil tannage similar to that described under Chamois Leather. The finished stock is usually hung out in the air to bleach.

In place of cod-liver oil, it has been found that other oils may be used. The author has been especially successful in substituting the oil from shark liver for cod-liver oil.

49. Lace Leathers.—Lace leather must be especially strong, as it is used for joining machinery belting. A good lace leather may be obtained by milling side leathers out of the bate in a mixture of cod oil and tallow. The milled stock is well set out and allowed to dry very slowly.

50. A process devised by the author and one which is giving very satisfactory results, consists in the use of a combination of alum and oil tannage. The process is carried out by using a short liming process followed by bating with oropon and then pickling with salt and sulphuric acid. The pickled stock is then milled in a 5° Be. salt solution, to which has been

added 7 per cent. of suphate of aluminum and 2 per cent. of borax. The stock, after being milled for 3 hours, is allowed to rest in the exhaust liquor overnight, after which it is set out, and hung up to dry. When bone-dry, the sides are sammied back to a 30 per cent. moisture content and milled with shark-liver oil. The amount of oil required is one-half gallon per side. One-fourth of the oil required is added to the stock in the mill and turned for one hour. A second quarter is then added and milled for another hour, and then the third quarter is added and milled for two hours. The stock is then removed from the drum and piled down overnight. The following day the stock is returned to the drum and the remainder of the oil added. The stock is then run for two hours, and with a lattice door run for another hour. From the drum the stock is well set out, rubbed with shark-liver oil and tallow, and hung up to dry. When thoroughly dry, the sides are sammied lightly and allowed to remain in piles overnight, care being taken that they do not overheat. They are then set out again, rolled, and hung up to dry.

51. Combination Tanned Buckskins.—On the weight of the pickled stock, triturate 5 per cent. of flour with a small amount of water. Dissolve 3 per cent. of sulphate of aluminum and 2 per cent. of salt in 20 per cent. of water. Slowly add to this solution 0.25 per cent. of sodium bicarbonate; mix in 1.5 per cent. of egg yolk and 0.1 per cent. of olive oil. Now add the flour paste. The skins being placed in the drum, the above mixture is introduced, the stock run for two hours, then left in the liquor overnight. The following morning the mill is run for one-half hour, the excess of liquor drawn, and a solution of 10 per cent. of gambier at 19° Bk. with 10 per cent. of salt introduced. The mill is run for 1½ hours. The stock is now fat-liquored with 3 per cent. of acid-fat liquor and hung up to dry. When perfectly dry, the stock is sammied, staked, buffed, and retanned with 5 per cent. of gambier, washed, set out, oiled off with glycerine, and tacked. After stuffing the stock is given a light season of flaxseed liquor and milk, rolled while damp, staked, dried, restaked, and blacked.

CHROME TANNING

52. A typical example of mineral tannage is the chrome process. This tannage is purely a chemical one, consisting of the combination of chromic oxide with the skin. This combination is evidently a chemical one between the skin and the oxide, as the product is not affected by washing or boiling, as are the products of bark tannages; neither is there any deposition of the oxide after the chemical union has taken place, even in the basic liquors used in one of the processes. Chrome leather is tanned either by the *two-bath process* or the *one-bath method.*

53. Two-Bath Chrome-Tanning Process.—The *Schultz process* of chrome tanning consists in treating the skins to a bath of dichromate of soda in the presence of a mineral acid. Following this, a bath of a solution of soda is given. The theory of this process is based on the formation of chromium oxide, having the formula Cr_2O_3, which is deposited on and combines with the skins. A solution of dichromate of soda and hydrochloric acid is made up in the proportion of about 5 pounds of dichromate and 2.5 pounds of hydrochloric acid, specific gravity 1.16, to every 100 pounds of wet prepared skins.

The reaction expected between the acid and the dichromate is

$$Na_2Cr_2O_7+2HCl=2NaCl+H_2O+2CrO_3$$

However, in the process, only two-thirds of the acid necessary for the complete reaction, is used, and it is not safe to say, considering the peculiar properties of chromium, that this equation exactly represents the reaction which takes place.

After the skins have been struck through in this bath, they are put into a solution of thiosulphate of soda and hydrochloric acid, which effects the reduction of the CrO_3 to Cr_2O_3. To neutralize the acid remaining in the skins, they are afterwards wheeled with water containing suspended calcium carbonate, or a solution of borax or sodium bicarbonate.

54. The use of practically all the agents that will reduce CrO_3, as hydrogen sulphide, the sulphides, bisulphites, etc., has been patented. Sulphurous acid seems to be the best, or, at least, it is one of the most generally used. Norris has patented the use of zinc in the hypo bath, which, it is claimed, accomplishes a more rapid and economical reduction.

By using sodium dichromate and sulphuric acid, it is possible to effect the reduction with sodium bisulphite and thus eliminate the production of free sulphur as is the case where sodium thiosulphate and acid are employed in the reducing bath.

Amend has a two-bath process in which chromic acid, H_2CrO_4, replaces the dichromate and an acid of the Schultz patent. This requires careful manipulation. He suggests the use of aniline as a reducing agent.

A chalk bath after the tanning bath neutralizes the hydrochloric and sulphurous acids remaining in the skins. Solutions of sal soda, sodium bicarbonate, and borax are also used for the same purpose. Norris has patented the use of potassium permanganate for this purpose. This salt not only oxidizes the sulphurous acid to sulphuric acid and neutralizes it at the same time, but it also precipitates the oxide of manganese on the skin, and this acts as a mordant in subsequent dyeing.

55. One-Bath Chrome-Tanning Process.—The one-bath chrome process of chrome-tanning, brought to perfection by Martin Dennis, and now used by many manufacturers, offers less difficulty than the two-bath system and has largely replaced it for all grades and classes of stocks excepting goatskins.

In this process only one bath is used; this is composed of a solution of a basic chrome salt that readily yields its excess of chromic oxide to the hide tissues. The tanning liquor, as originally prepared, was made by dissolving oxide of chromium in hydrochloric acid, thus forming the normal chloride. To this was added an alkaline base, as sal soda, this stronger base taking from the chromium chloride part of its acid, leaving

the oxy, or basic salt. This basic salt is a very unstable compound and readily yields its excess of chromium to anything having an affinity for it, which, in this case, is the hide substance. The advantages of this system over the two-bath system are as follows:

1. One handling of the skins is saved, because one bath only is needed for the tanning.

2. The skins are not exposed to the destructive action of chromic acid, and are therefore stronger, with more lasting suppleness, and have a better grain.

3. There are no offensive fumes evolved in this process; the reduction of the oxide in the two-bath process is accompanied by a strong odor of sulphur dioxide.

4. The skins are not harmed by too long contact with the tanning liquor.

5. Less skill is required to operate it and the bath itself is cheaper.

56. The practical operations of tanning by means of the one-bath system are as follows:

The skins or hides are soaked, limed, unhaired, fleshed, and bated as usual. From the bate they are taken to a drum and pickled with a solution of salt and sulphuric acid in the proportion of 12 per cent. salt with $1\frac{1}{2}$ per cent. of sulphuric acid at a density of 12° Be. This keeps the skins open and plump and also has the effect of keeping them in good condition during and after tanning. From the pickle they are put in the tanning bath, which contains a solution of the concentrated basic chrome liquor, 3 per cent. of Cr_2O_3 on the weight of the stock, and also 10 per cent. of common salt. This common salt prevents the grain of the leather from drawing under the astringent action of the chrome bath.

When the skins have assumed a uniform greenish-blue color and a cutting reveals the completion of the process, they are neutralized with 1 per cent. of sodium bicarbonate and horsed up overnight. The next day they are rinsed in clean water and worked on the flesh side with a slicker on a perfectly

clean table or they are set out on the machine. They are next shaved and sorted for colors and blacks.

57. Since Martin Dennis made practical use of one-bath chrome liquor, many other concerns have entered the field. As a result of investigation, many methods for preparing one-bath chrome liquors have been developed. The simplest method of preparing this liquor, and the one used by many tanners, consists in reducing sodium dichromate in the presence of an acid. A formula which gives very satisfactory results is as follows:

Dissolve 20 pounds of sodium dichromate in 25 gallons of water. To this add 10 pounds of sulphuric acid and 20 pounds of salt. In a separate container dissolve 22 pounds of sodium bisulphite in 10 gallons of water, and add this solution very slowly and with constant stirring to the solution of chrome. The resulting liquor should be blue-green in color; if not, a little more sodium bisulphite should be added. When completely reduced, add enough water to make 40 gallons and use this as a stock solution. To tan with this liquor, use 8 gallons for each 100 pounds of the pickled stock.

58. Characteristics of Chrome Leather.—Chrome leather has special and peculiar qualities that distinguish it from other kinds of leather and which make it a superior article. It is not actually waterproof, but rather a moisture resister. It is a difficult matter to wet it thoroughly when once perfectly dry.

The ordinary bark tannages are compounds of two organic materials and when they are subjected to alternate wetting and drying, they will eventually deteriorate and become rotten. Chrome leather, being a combination of an inorganic material with the hide substance, is not affected by wetting and drying. It is lighter than bark leather and also possesses more elasticity and is of greater strength.

59. Chrome Combination.—For certain uses straight chrome leather does not answer all of the requirements. Tanners have, therefore, found it desirable to after-treat or retan

the chrome stock. This is done by running the skins in a solution of some vegetable tanning material. The so-called washable cape leather used extensively in glove manufacture is produced by first tanning the skins in chrome and subsequently retanning in gambier extract. The skins are then well fat-liquored, dried, sammied, staked, buffed and colored.

60. Fat-Liquoring.—The finishing, or currying, of chrome leather is carried out with some modifications of the methods used for finishing bark leather. Chrome leather must be stuffed soon after removal from the tanning bath and must not be allowed to become dry. The most efficient way of stuffing chrome-leather is by *fat liquoring.* There are different ways of making and using these fat liquors, depending on the quality of the leather to be produced.

The fat liquor most commonly used consists of some form of sulphonated oil which produces an emulsion with water and which is readily taken up by the stock. Soap mixed with neatsfoot oil is very largely used in the fat-liquoring of goatskins for glazed kid. Either sulphonated oil or soap may be employed to carry in other materials such as egg yolk, degras, cod-liver oil, and the like. The amount and nature of the oil used regulates the character of the finished product; the more oil employed, the softer will be the resulting leather.

61. There are on the market many varieties of chrome leather that are sold under different trade-names. When these varieties of leather represent the product of straight chrome tannages, the actual tannage of each particular brand is carried out in the same way, the differences that characterize them being due to the amount and character of stuffing, character of the finish, and the style of grain given the finished leather.

62. Box Calf.—The variety of leather known as box calf is generally made in the following manner: The skins are soaked, limed in a mixture of lime and red arsenic, or of lime and sodium sulphide, fleshed, unhaired, and bated. They are then pickled in a solution of sulphuric acid and salt and

tanned by either the one-bath or the two-bath chrome process. The skins are then pressed in a hydraulic press, or worked out by hand or machine, and shaved to give the flesh side a smooth surface. They are then stuffed, or fat-liquored, and colored. After hand or machine setting out, to remove the excess water, they are dried simply by hanging them over poles in the loft. When the leather is dry, it is packed in damp sawdust, and when properly sammied, it is staked by machinery. The well-staked skins are then tacked out on frames and allowed to dry under tension. When thoroughly dry the skins are *stripped* from the boards and given a coat of season. This season may be made up in several ways but usually contains some gelatinous or albuminous material to which coloring matter has been added. The commonest color is black and is produced by adding a solution of logwood and iron to the compound. The skins after seasoning are hung up to dry. When the season has become set and the skins are thoroughly dry, they are glazed on the machine and a second coat of season applied. The skins are again glazed, which operation may be repeated several times before boarding. The *box* grain of the leather is given by a workman, who has a cork-covered boarding tool strapped to his forearm. The boarding tool is applied to a fold of the leather, and the characteristic grain imparted to the leather by the motion and pressure exerted by the workman.

63. Bright Finish Calf.—In producing a bright finish on chrome calf, the same operations are carried out as for box calf, except that a shorter liming is applied and the final glaze finish contains either blood or egg albumen. The operation of boarding is, of course, omitted.

64. Matt Calf.—When a dull finish is required, the same operation is carried out as for bright finish except that the season employed does not contain any albuminous material. The dull effect is produced on a smooth plate machine or by the application of a hot flatiron. After ironing, the stock is oiled off with a light mineral oil which gives the final pleasing appearance to the leather.

65. Glazed Kid.—Goat skins, usually imported in a dried state, are used in making both glazed, white and dull kid, although some sheep leather and even some light grain splits are sold to be used in *glazed-kid shoes*. The dried goat skins are well soaked and then painted on the flesh side with a mixture of sodium sulphide and lime. This attacks the roots of the hair, loosening it, and causing it to slip easily. After painting, the skins are folded along the spine, flesh side in, and piled in low piles to lie overnight. In the morning the hair is removed and the skins limed. In the lime liquor a mixture of lime and red arsenic is used. The skins after beaming are washed in paddle wheels to remove some of the lime and sodium sulphide used for unhairing. After fleshing, the skins are bated, or puered, with dog-manure or oropon to the proper condition for tanning. Either the one- or the two-bath chrome process is used for tanning, the latter being the more popular. After being run in the first bath in a drum, the skins are removed and set out on a machine, or pressed in a hydraulic press, to remove the excess of liquor. They are then dipped by hand in a solution of hydrochloric acid and hyposulphite of soda and placed in covered piles. This hand-dipping is for the purpose of reducing some of the chromium solution on the surface of the skins. The next day the skins are taken from the piles and run in a drum with the second bath, which reduces and fixes the chromium oxide on the fibers. Some tanners prefer to neutralize in a paddle rather than in the drum.

66. When the reduction is complete, the skins are run with sodium or bicarbonate solution until the free acid has been neutralized, and finally they are washed with clean water. The skins are then set out by hand or by machine to remove the excess of water, fat-liquored, and given the desired color, after which they are worked by hand or machine to remove moisture and to give them a soft silky grain and also to stretch them. The skins then receive a light coat of glycerine, or of glycerine and oil, on the flesh side and are dried on poles in a warm drying-loft. When thoroughly dry, they

are taken to an airy loft, thrown in piles, and left to temper for 7 or 8 days, during which time they absorb atmospheric moisture, and soften. After tempering, the skins are packed in damp sawdust, which brings them to a proper condition for staking. The staking is done either by hand or by machine, the smaller and lighter skins being generally hand-and-knee-staked, while the machine is used on the larger and heavier skins. After being thoroughly broken and softened by the staking, a coat of heavy seasoning is applied, and after this is dry the skins are lightly glazed on a glazing machine. Seasonings vary in composition with the finisher, but they are generally compounds of such materials as blood albumen, egg albumen, algin, etc., and are colored to match the color of the leather that is being finished. After the first seasoning and glazing, a second coat of lighter seasoning is applied, and the leather receives a heavier glazing on the machine. A final light coat of seasoning is applied, and the skins are then glazed with a heavy pressure, after which they are laid away to be inspected, sorted, measured, and packed for shipment.

67. For dull-finished leather, a heavier stuffing, or fat-liquoring, is given the most perfect of the skins and, instead of being glazed by the machine, they receive a light coat of paraffin oil and are ironed by hand with a hot flatiron. They may then receive another coat of oil and receive a final ironing.

68. Chrome side leather is made by soaking, liming, unhairing, fleshing, and bating the whole cowhide, and then pickling it in salt and sulphuric acid, and splitting. The grain split is then chrome-tanned and the subsequent finishing processes are the same as for either glazed or dull kid. Heavier grain splits may be tanned and finished in a manner similar to that employed with chrome calf, and frequently the entire cowhide is chrome-tanned before splitting.

69. Chrome Patent Leather.—Whole skins, such as calf, goat, and kid, or split cowhides and steer hides are used in making *enameled,* or *patent, leather* for shoes. The actual tanning processes for leather to be coated are similar to the

methods of tanning different skins or hides into other light leathers. The fat-liquoring and seasoning vary somewhat, but up to the point of enameling, the process is not materially different.

70. A patent shoe leather made from chrome-tanned cowhide splits is made by the following process: The hides are soaked, split into sides, fleshed, depilated with lime and sodium sulphide, washed, and bated. They are then pickled in a solution of sulphuric acid and salt, and are either pressed or put through a wringer and then sent to the splitting machine. The grain split is used for making the patent leather, and after being shaved on the machine to give it uniform thickness and to make the flesh side smooth, it is tanned by a one-bath chrome process. It is then fat-liquored and colored, the flesh receiving a purple color before the main dyeing takes place. After setting out by hand or on the machine, the grain side receives a light oiling, and the split is then sent to the loft and dried. When dry, it is packed in wet sawdust, then staked by the machine and carefully tacked. The leather on being stripped is usually degreased and is then ready to receive the enameling compounds. These are made in various ways, the pastes used on the first coats being generally made by boiling down linseed oil with lampblack and adding naphtha to thin them. Other oils and mixtures are used for this purpose, their ingredients differing with each foreman, who endeavors to keep his competitors from securing his formulas. The leather is stretched and tied to frames, after which the first coat of daub is rubbed on and worked over the surface evenly, all surplus being removed by means of a slicker. When the first coat has dried, a second coat of the same material is applied in the same manner, and the frame, with the leather, is placed horizontally in a large oven to dry. If other coats are to be applied before the top varnish, they are put on after this drying and the frame returned to the oven. When the leather is ready for the top varnish, it is gone over with pumice to make the surface perfectly smooth and to remove pimples. The dust from this operation is brushed off the leather, or

blown off by a jet of compressed air. The top varnish is applied in a warm, dust-proof room, into which the ovens open. It is thinner than the previous coating solutions and varies in composition. Linseed oil, organic gums, pyroxylin, or guncotton, camphor, amyl acetate, wood alcohol, and castor oil are among the ingredients of the various daubs and varnishes used for coating leather, and probably no two factories use the same formula. The top varnish is applied to the leather with a broad, long-bristled brush similar to a whitewash brush. In applying this top coat, great care is taken to spread it evenly and to leave no bubbles or dust or hair marks.

After receiving the top varnish, the frame is placed in the oven and the skin dried, and after the oven drying it is taken into the air to receive a final sun-and-air drying, which removes any tendency to stickiness. When thoroughly dried, the finished leather is cut from the frame, trimmed, and measured, when it is ready for shipment.

71. Chrome sole and belting leathers are being made in constantly increasing quantity, although as yet this class of tannage has not become common. The sole and belting leather produced by the chrome-tanning process has not the weight of the bark-tanned leather it aims to supersede, and its cost is accordingly higher. The cowhides or steer hides from which these kinds of leather are made, go through the regular beamhouse processes, being bated so that all the lime is removed from the hides. Then they are pickled in a solution of sulphuric acid and salt, and when drained after removal from this solution they are ready for the tanning. The one-bath chrome process has been found most suitable for this class of leather. The pickled hides are usually tanned on the paddles, as the constant tumbling of such heavy stock in a drum is apt to produce a loose grain. The liquor is first made up by preparing a 10° Be. salt solution and then adding an excess of the one-bath chrome liquor. The time of the treatment varies from 12 to 48 hours, depending upon the nature of the tan liquor. A few tanners carry on the operation in rocker pits, but such practice is not very common.

After being tanned so as to stand the boil, the hides are removed from the paddle and horsed up overnight. They are then shaved, neutralized, washed, and fat-liquored. For sole leather the fat-liquoring is only slight and some tanners do not give the hides any oil. Where the stock is fat-liquored, it is tacked while still wet and allowed to dry under tension. This drying under tension results in a stiff leather which is desirable for this kind of stock. If the leather is to be made waterproof, it is dipped into hot wax and immediately transferred to the hot room to drain. Some shoe manufacturers prefer to purchase the chrome sole and do their own waterproofing.

When heavy chrome leather is to be used for belting purposes, it is fat-liquored somewhat higher than sole leather but is afterwards dipped to make it stronger and more waterproof. In place of tacking, leather to be used for belting is usually cut in strips and dried under tension in stretching frames.

72. Chrome Combination.—Straight chrome sole leather is more difficult to work then vegetable-tanned stock and does not channel or buff very satisfactorily. This objection may be overcome by retanning the hide with a vegetable tanning agent. A ten-day treatment with 40° Be. extract will fill the stock, add weight, and improve its appearance. Stock which has been retanned in this way may also be loaded in the extract wheel and made to carry considerable weight. Chrome retanned leather is usually waterproofed in the same manner as straight chrome. Chrome retanned sole leather may be worked like vegetable-tanned stock and can be channeled and burnished with ease.

DONGOLA LEATHER

73. An example of a combination vegetable and mineral tannage is found in the so-called *dongola leather*. Originally, the dongola tannage was a combination of alum and gambier, but dongola leather is now made with vegetable combinations other than gambier. Hemlock and oak liquors are sometimes

used in combination with gambier, and quebracho extract is also a popular material for use with gambier. This class of tannage is applied to calfskins, sheepskins, goatskins, kidskins, and side leathers.

74. Preparation of Dongola Leather.—After coming from the beam house, the skins are bated and washed and then pickled in a solution of sulphuric acid and salt. After pickling, the skins go into the tan liquor, which is made up of gambier, gambier and quebracho, gambier and hemlock, etc., to which is added a solution of alum and salt. The tanning takes place in rockers or in paddle-wheel vats. In some tanneries, the stock is given the mineral and then the vegetable tanning, the skins being first tawed in the alum and salt liquor and then tanned in the vegetable tan liquor.

After tanning, the leather is washed in a wheel, pressed or wrung, and then shaved; if splitting is necessary, it is done at this stage. Sometimes, the heavy hides are split out of the pickle, the flesh splits being tanned by a dongola process, while the grains are finished by a chrome process.

After shaving or splitting, the leather generally receives a wheel treatment with a pure gambier or sumac liquor. Splits are retanned in gambier or quebracho liquor in a wheel, or they may be returned to the original tanning vats.

From the sumac wheel, the leather is piled on horses and allowed to drain overnight; or, it may be set out immediately and then stuffed. The stuffing is done by a fat liquor generally made of soap, cod oil, and degras. Frequently, the leather is given two stuffings, the first being a straight-oil combination, such as neatsfoot and cod oils. Then, after drying and redampening, the leather is again stuffed with a fat liquor. After stuffing, the leather is dried. When dry, it is dampened in a wheel with warm water and is then colored and finished according to the character and appearance desired in the finished product.

LEATHER DYEING

75. Dyeing and Finishing of Leather.—Dyes are applied to leather by brushing by hand or on the machine, by means of the paddle, or mill, or on the tray. In the brushing method a solution is spread evenly over the grain on the flesh side by means of a stiff brush and then hung up to dry. In tray dyeing the skins are either folded down the back or two skins are placed flesh to flesh and then drawn several times through the color solution. When a large number of skins or sides are to be dyed the same color, the paddle or mill is employed. In paddle coloring, the necessary quantity of dyestuff is dissolved in the water and while the paddle is turning the stock is carefully introduced. By far the largest amount of leather is colored in the mill, in which case the skins are placed in the drum and enough water introduced to cover the stock. The mill is then set in motion and the color solution slowly added through the trunnion.

In coloring leather both natural dyewood extract and coal-tar colors are applied. Of the natural dyes, logwood, fustic, and osage orange are most commonly used. Of the coal-tar colors, basic acid, direct and alizarine dyes are employed.

As the methods used for coloring chrome-tanned leather may be applied equally well to vegetable-tanned stock, we will illustrate the various procedures on this kind of leather.

76. Black.—The shaved stock, after being weighed, is placed in the mill and enough water at 125° F. added to float the skins. One per cent. hematin on the weight of the stock is dissolved in water at 125° F. and, being made alkaline with ammonia, is introduced through the trunnion while the drum is in motion and turned for fifteen minutes. One and a half per cent. of direct leather black is dissolved in water at 145° F. and added through the trunnion to the contents of the drum and run for 15 minutes longer. Without removing the excess of color, a sulphonated oil fat-liquor is introduced into the mill turned for another half hour. The stock is then washed, oiled off with Setine No. 2 and hung up to dry.

77. Dark Tan.—The shaved stock is placed in the mill and sufficient water added at 125° to float the stock. While the mill is in motion a solution 3 per cent. of fustic is introduced through the trunnion and the milling continued for one-half hour. A solution of one-fourth of one per cent. of potassium titanium oxalate is now added and run for 15 minutes. The stock is then washed for 5 minutes with warm running water, enough being allowed to remain to float the stock, and the following dye solution introduced. For each 100 pounds of skins make up

Flavo phosphine G. G. Conc., 22 oz.; vesuvine R., 3 oz.; methylene blue B., ¼ oz.; water at 140° F., 10 gals.

While the mill is in motion one-third of the color is introduced through the trunnion. At the expiration of 5 minutes a second third is added, and after another 5 minutes the final portion is introduced. The mill is then run for one-half hour, the stock washed in running water and fat-liquored with a good grade of sulphonated oil. The skins should then be set out carefully and hung up to dry.

78. Dyeing with Acid or Direct Colors.—The shaved skins are placed in the drum and sufficient water added at 125° F. to float the stock. The color solution is prepared by dissolving the necessary quantity of dyestuff in water to which is added about 1 per cent. of borax. The color solution is introduced in 3 portions and the stock milled for one-half hour. By this time the color has penetrated the leather and is set by adding 3 per cent. of formic acid diluted with water and run for 15 minutes. The excess of color is drawn off and the stock fat-liquored with sulphonated oil. The skins are then set out and hung up to dry.

79. Sammie.—The skins as they come back from the dry-room are stiff and so must be softened back. This is done either by dipping in warm water and placing in piles to sammie or they are packed down in damp sawdust for several hours.

80. Staking.—In order to stretch the skins they are worked in a staking machine.

81. Tacking.—After staking the skins are sent to the tacking loft and while still damp are carefully tacked on frames and allowed again to dry.

82. Finishing.—On stripping from the frames the skins are given a coat of season and while slightly damp, are rolled on the jack. They may then be finished in matt or bright as desired by using the proper solution and either ironing or glazing.

MEASUREMENT OF LEATHER

83. Sole leather is always sold by weight, but light leathers are sold by area, the approximate thickness also being taken into consideration. The measurement of leather is now

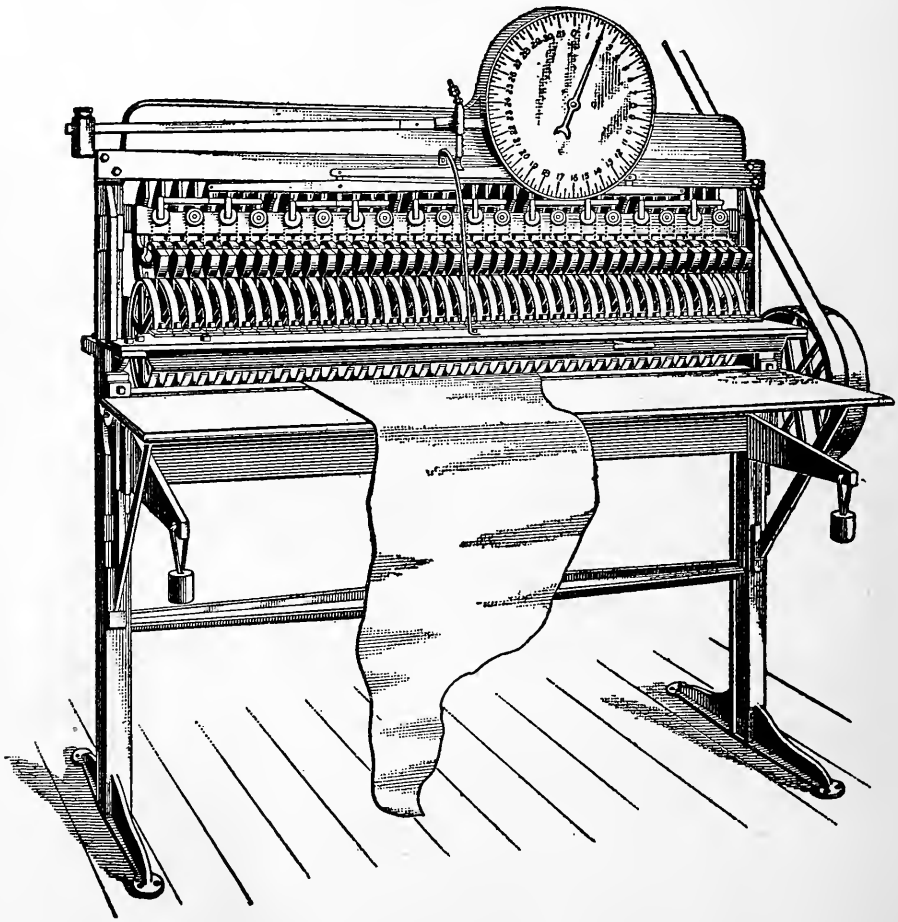


FIG. 13

usually done by means of machines, of which there are several on the market. Some of these vary essentially in principle, but the descriptions of the Sawyer and Union measuring machines given here will be sufficient to show their application.

84. Sawyer Measuring Machine.—The Sawyer leather-measuring machine, shown in Fig. 13, is run by power. The leather is fed between two rollers that smooth it out and bring it into contact with small measuring wheels. The movement of these wheels influences properly arranged levers, which, in turn, affect the index of the registering mechanism.

85. Union Measuring Machine.—The Union leather-measuring machine, shown in Fig. 14, consists of a table with a top made of parallel sticks of wood. A hinged cover closes

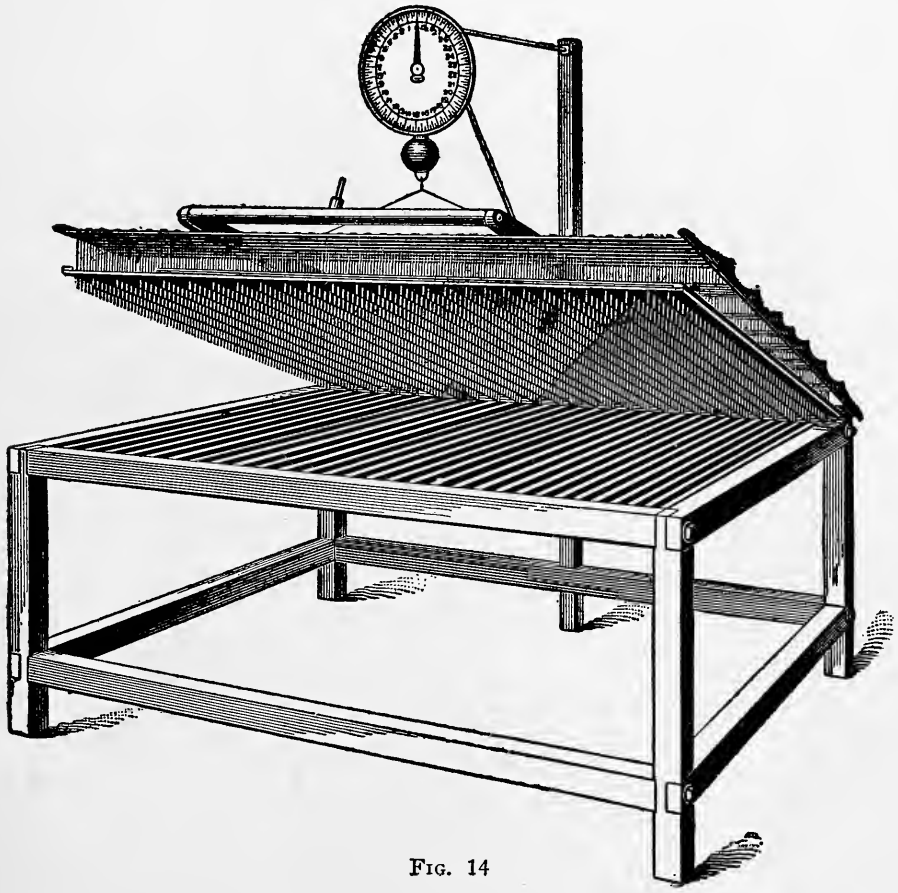
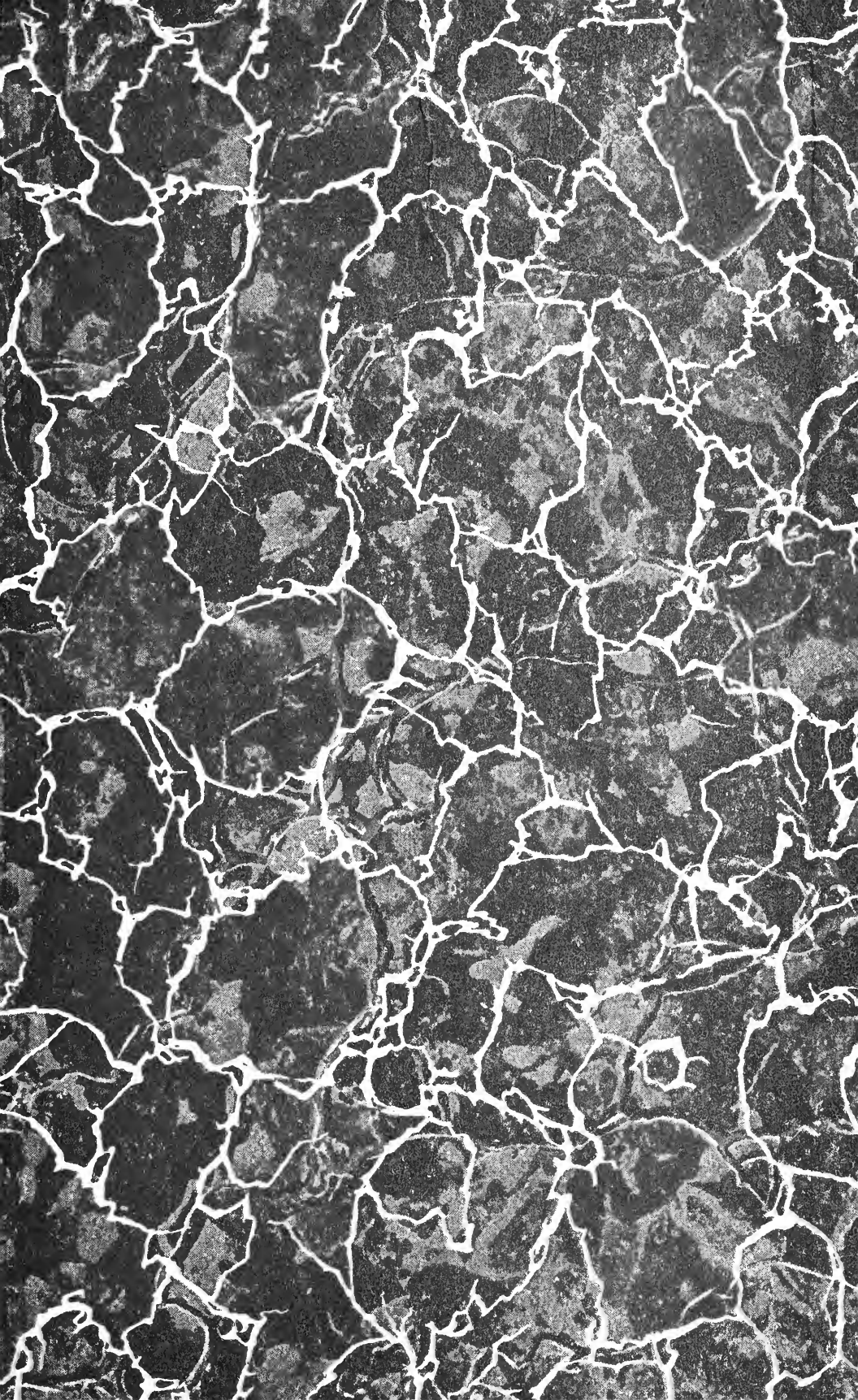


FIG. 14

over this, and throughout the entire surface of this cover are suspended small wire pins that are free to slide up through holes in the cover. The pins are arranged in rows, so that when the cover is down, with nothing between, the pins hang between the strips of wood forming the lower table.

When leather is to be measured, it is placed on these strips and the top brought down over it. The surface of the leather obstructs the small pins and throws them up, the ends of the remaining pins dropping between the strips. These pins are of such sizes and weights that each exercises the same force on a spring balance above, so that this device is affected by the number of pins obstructed by the leather. The weight of forty-eight of the pins corresponds to a square foot of area, and the dial of the balance indicates, in fractions of a square foot, the weight released by the leather, and consequently the area of the leather.



LIBRARY OF CONGRESS
0 016 055 343 1